MAY 1987

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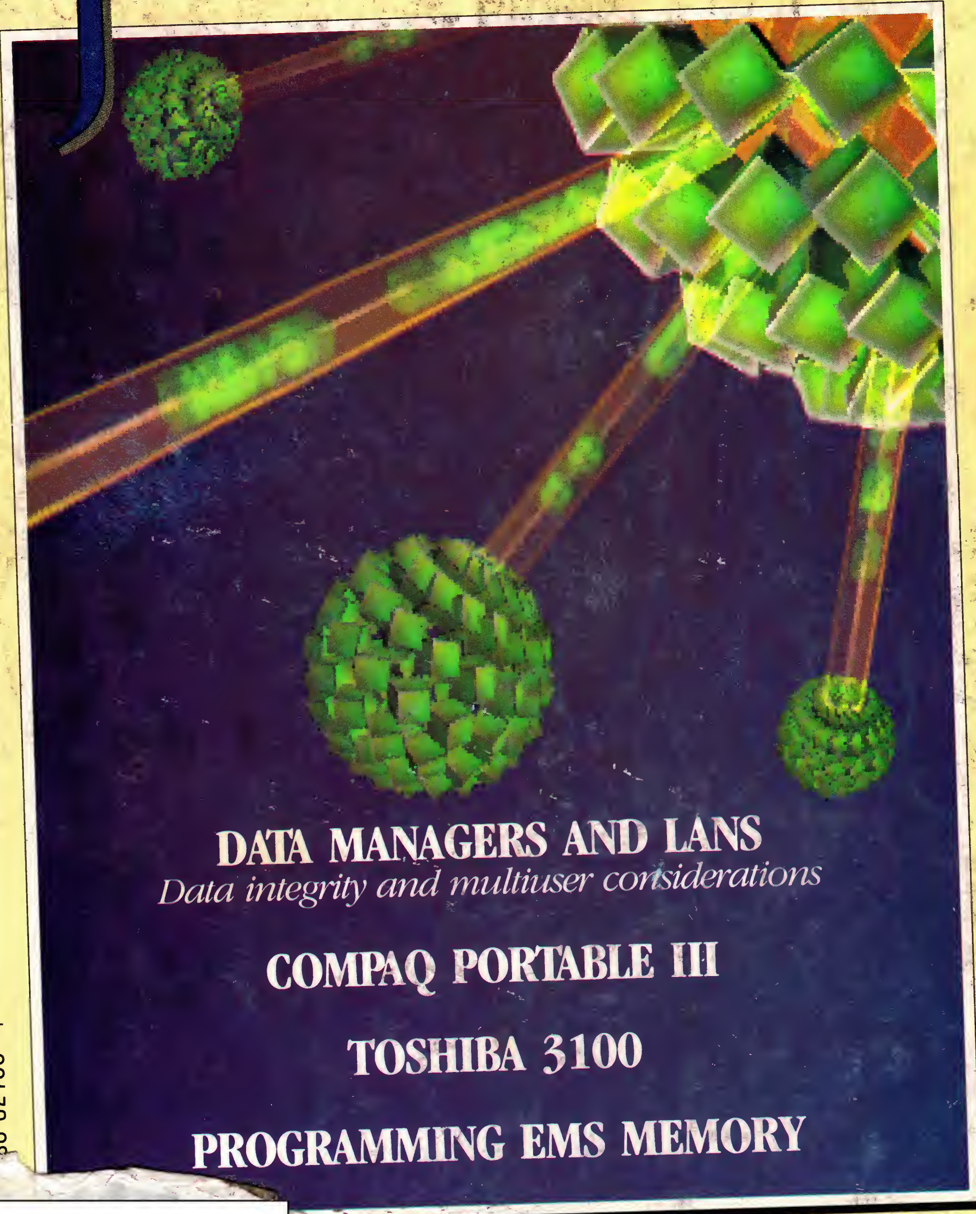
FOR THE SYSTEMS PROFESSIONAL

PC TECH JOURNAL®



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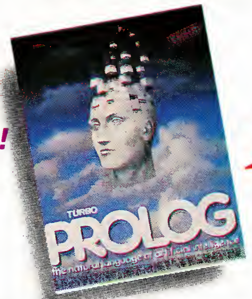

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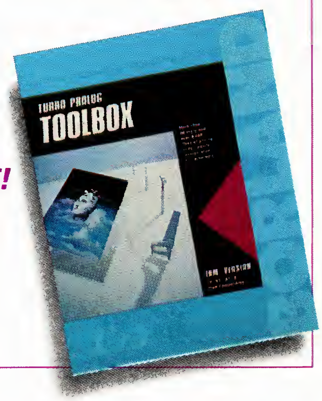

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TECH PC JOURNAL

MAY 1987

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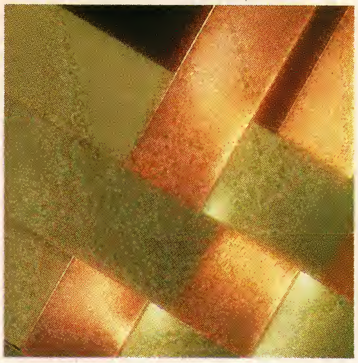

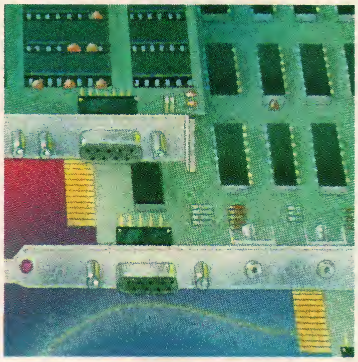

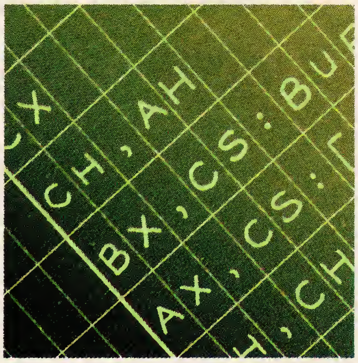

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■ ***Features to whet your appetite.*** Periscope III is the most comprehensive, flexible, and easy-to-use product of its kind! Here are just a few of its features:

- Set hardware breakpoints on up to 16 ranges of memory and I/O ports
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■ ***Protect your investment.*** Order Periscope with confidence because it's a proven product—it does its job and does it well. Periscope's been on the market for over two years and it keeps getting better. The only debugger ever chosen Product of the Month by PC Tech Journal, Periscope is used daily by thousands of developers who depend on its flexibility and robustness.

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You get technical support and your first software update free of charge. We notify you of subsequent updates for which there's a nominal charge, currently $20.

Once you learn Periscope's commands, you can easily use any model. Only when extra commands are needed to deal with model-specific hardware (there are an additional dozen commands in Periscope III) are there any differences.

You can always trade up to another model of Periscope for the difference in price plus a small fee, currently $10. With the release of Periscope III, there's a model that fits virtually every developer's needs and budget.

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Ask current users about Periscope's price/performance. They tell us that Periscope pays for itself in a matter of hours, and that they can't live without it!

Periscope III includes a board with 64K of protected program memory, hardware breakpoints, & a real-time trace buffer; a break-out switch; software; a 200-page manual; & a quick-reference card, all for $995 (8 MHz) or $1095 (10 MHz).

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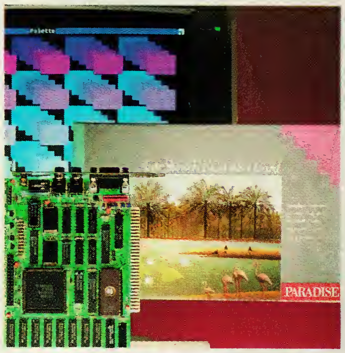

In other words, we've "consolidated the best features of other EGA clones into one board, and added an automatic (software) switching feature," **(Infoworld 7/86)** that "work(s) flawlessly." **(Byte 1/87)**

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And that was before we introduced the **Autoswitch EGA 480 Card** with **132 column mode, 480 vertical line resolution**, and extended our already **unbeatable range of software applications support**.

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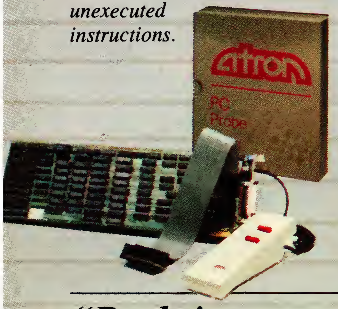
WHO YA GONNA CALL? BUGBUSTERS!

This is how PROBE displays real-time trace data. Trace information includes C source code, assembly language and data which was read or written during instruction execution. PROBE software simplifies the display by tossing out prefetched but unexecuted instructions.



PROBE knows all about your local and complex variables. You can display and change an array of structures as easily as shown in this display.

PROBE's menu window means you do not have to look up debug commands in the manual. Entering the command name shows you command syntax.

"Real-time source-level debugging of very large programs simply can't be done without Atron's AT PROBE." *Ed Oates, Director of PC Software Development, Oracle Corporation*

The good news with your new Microsoft 4.0 or Lattice* C compilers is that they're providing more symbolic debugging information than ever. The bad news is you can't fit your program, a software debugger and that monster symbol table into memory - at least at the same time.

The great news is that Atron's AT PROBE™ hardware-assisted software debugger not only has 1-MByte of onboard memory for debugger and symbol table, but it now supports local variables and complex data types.

The AT PROBE is a debugging tool that plugs into your PC AT and monitors everything the processor is doing. In real time.

REAL TIME DEBUGGING.
SOONER OR LATER, YOU KNOW YOU'LL NEED IT.

The AT PROBE's hardware-assisted breakpoints trap on reading, writing, executing, inputting and outputting. On single or ranges of addresses, including particular variable values. All in real time. For a mere software debugger to attempt this, a 1 minute program would take 5 hours to execute.

OPTIMIZED CODE - GOOD, BAD AND UGLY

The good news is optimizing compilers generate very tight code. The bad news. The time to debug optimized code is inversely proportional to the quality of the optimizer. Figuring out how in the world you ended up somewhere gets ugly, fast.

With AT PROBE's real-time trace capability, program execution history is saved on-board, in real time. Once a hardware trap has occurred, PROBE displays the program execution in detail, including symbols and source code. Real-time trace can show you how out-of-range pointers got that way. And there's really no other way to debug interrupt-driven code.

AT PROBE OPTIMIZES THE OPTIMIZED

When the job of bugbusting is done, your AT PROBE becomes a performance analyzer. So you can have both reliability *and* performance. So you can send only the best software into the field.

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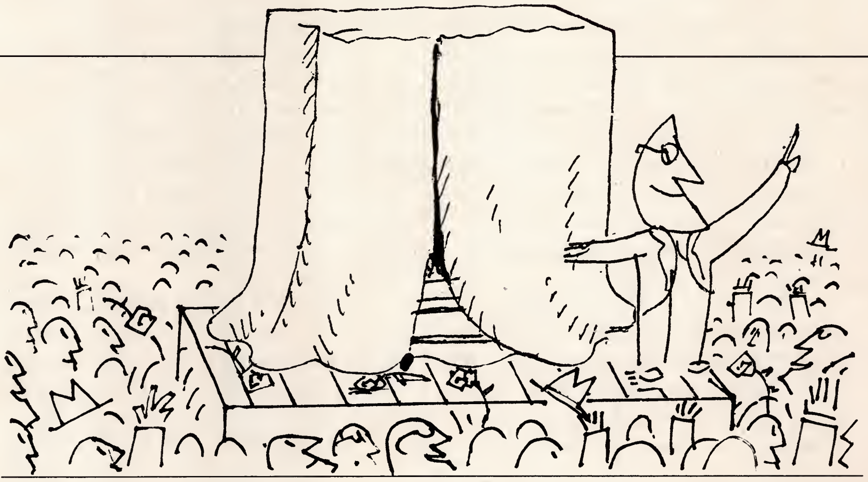

ILLUSTRATION • MACIEK ALBRECHT

IBM's new desktop computers have finally arrived, ending at least a year of speculation about how IBM intended to reestablish its dominance in a market it has been watching dribble away. Its answer: a completely new family of systems, called IBM Personal System/2, largely compatible with the PC, PC/XT, and PC/AT, and offering a clear migration path to the future. The new family, the end result of IBM's careful study, embodies many difficult decisions and indicates the company's willingness to stage a tough battle in the reshaped personal computer market.

How good this family is for IBM depends ultimately on how good the systems are for users. Understanding System/2 is not easy, and answers to our questions cannot be derived from spec sheets. System/2 is a "real" computer with a "real" bus and (in about a year) a "real" operating system. In those two realities lies the true meaning of IBM's new offering.

Before revealing those truths, however, two important aspects of the new systems bear comment.

5.25-INCH – 1.75-INCH = 1.44MB

Controversy will swirl around IBM's decision to incorporate 3½-inch diskettes in all the System/2 models. I am on record as favoring the 3½-inch standard and, notwithstanding the strident mail I received the last time I mentioned it in this space (June 1986), I still favor it. The advantages of ruggedness, reliability, size, and capacity are just too compelling to ignore and, in the final analysis, IBM must have thought so as well.

For the long term, the 3½-inch standard is the right decision. For the short term, it is certainly problematic. IBM has addressed the data interchange problem by offering several choices: 3½-inch diskettes for older machines, 5¼-inch diskettes for some of the newer models, and a rather elegant solution involving the System/2's bidirectional parallel port and a $33 cable and software package.

IBM also offers its users a teaser. The System/2's high-density 1.44MB diskette has 16 percent more storage capacity (approximately 200KB) than the AT's 1.2MB 5¼-inch diskette.

The 3½-inch decision took courage. That done, IBM need only wait out the storm. With most major software vendors already able to ship their products in this form, I think 3½-inch diskettes should settle in as a standard that, in hindsight, we will appreciate.

Another important decision IBM made for the System/2 is its Video Graphics Array (VGA). Display options have always been a headache for the PC buyer. From day one, we were confronted with a choice between monochrome or color, text or graphics. Ultimately, IBM priced itself out of the market; who, today, will pay more than $1,700 for IBM's Enhanced Graphics Adapter (EGA) subsystem?

IBM's new VGA works out several problems for IBM and reduces the number of purchase decisions for the buyer. IBM benefits because it is once again selling the graphics capability and because it has the only game in town for the display, at least for the moment. IBM also benefits because the number of possible configurations is far smaller, so IBM and its dealers have fewer parts to stock, sell, and service.

The buyer benefits because there is less to understand. The graphics capability comes built-in with every machine. For some special applications, a high-resolution (1,024 by 768) adapter may be specified. The buyer must choose one of four display options: 12-inch black and white, 12-inch color, 14-inch color, or 16-inch color.

The VGA is "free," and the 14-inch color display *lists* at a very competitive $595 and will drop to under $500 on the street. Street price for an EGA-compatible board and NEC MultiSync monitor is between $900 and $1,000. So the VGA provides its nice new resolutions, large number of colors, and EGA/CGA emulations for half the price of an EGA.

TRUE MEANING

System/2 can be criticized on a number of points. The clock rate of 10 MHz is a bit slower than other AT compatibles (Compaq, for example). Increasingly, however, the decision to buy computers must be made for the long term; the design of System/2 indicates attention to the fact that a desktop computer should deliver value for more than two or three years. The significance of the new family centers on two factors: the bus and the operating system.

Except for the low-end Model 30, the System/2 family has an architecture dramatically different from the PC family. This is most evident in the Micro Channel bus, which bears no resemblance whatsoever to the PC or AT bus. Abandoning the original bus was a necessary evil; we should think twice before criticizing IBM too sharply for leaving all those add-in products behind.

The significance of the new bus is not that it is 32-bits wide. In fact, IBM built a 16-bit version for the Models 50 and 60, and a dual 16/32-bit version for the Model 80. The true meaning of the bus is that it brings the kind of technology that minicomputers have enjoyed for years to low-end, personal systems.

PC Tech Journal will devote much attention to the Micro Channel in a forthcoming review of the System/2. A few highlights illustrate the advantages of this new bus architecture.

To begin with, the bus signals are now level-triggered instead of edge-triggered. This means that noise on the bus is less likely to be mistaken for a valid signal. IBM has used other techniques to improve the electrical reliability of the bus, with the benefit of increased data integrity and reliability.

Many new signals have been added to the bus that enable testing and diagnostic procedures to be implemented. Each board plugged into the bus must have an ID; the power on software uses this ID to configure the system automatically by, for example, initializing a board's hardware registers with data stored in the system's nonvolatile memory. The ID can also be used to determine that a board is missing or that it has been relocated to another slot.

A board can be ordered to isolate itself from the bus, allowing the board to be removed from the computer while it is running and another board installed in its place. The system can then allow the new board to connect and begin operation. This is a dramatic increase in sophistication for a machine in this price range.

Finally, the bus is arbitrated. Unlike the PC, in which the system is the master, up to 15 masters may reside on the Micro Channel. These masters are very much peers; they can ask for the bus, they can demand it, and they can obtain all services available through it. A few safety valves have been designed so the system board can regain control to handle severe error conditions.

The second true meaning behind IBM's new family is the operating system still to come, Operating System/2.

The version of OS/2 that IBM is promising for early next year, the Standard Edition, is what most of us have expected. It will support the protected-mode operation, allowing both larger applications and more than one application to run. It will have windowing and graphics capabilities embedded in it.

The real excitement lies in the Extended Edition of OS/2. This version will include all features of the Standard Edition, plus two major subsystems, the significance of which is indicated by the $795 price.

The first subsystem will be a complete, relational data management system. The data management capabilities become, in effect, an integral part of the operating system, accessible to the developer just as the disk and file functions of PC-DOS are today. Furthermore, IBM says that the facility will be compatible with its mainframe products and will understand and process SQL.

The second subsystem will be communications. IBM says that this section will include intersystem communications, connectivity, and terminal emulation. It is safe to guess that the software will improve the ease and flexibility with which System/2 can be connected to larger systems and networks.

The combination of data management and communications is precisely what is needed to achieve the connected PC. IBM is committing itself to a solution that is increasingly important in Corporate America—and just in the nick of time. Larger firms are accelerating the pace at which LANs and other communications solutions are being installed. Until Extended OS/2 is in place, IBM will continue to play second fiddle to its own aftermarket.

THE BOTTOM LINE

The price of the Model 60 with a 40MB disk and color display is $5,890, or about the same as a similarly equipped AT 339 with a third-party EGA. That is a very attractive price considering the additional performance, greater disk capacity and improved graphics capability. Competitive pricing, enhanced reliability, and a design for the future yield a system family of which IBM can be proud. System/2 represents a leap forward for all of us.

WHAT IBM ANNOUNCED

Personal System/2 consists of four models, designated the Models 30, 50, 60, and 80. Model 30 is the baby and is based on the 8086 processor clocked at 8 MHz and 640KB of zero-wait-state memory. Models 50 and 60 are based on the 80286 at 10 MHz with 1MB of one-wait-state RAM. Model 80 is based on the 80386 at 16 MHz with 1MB of one-wait-state RAM; a version of Model 80 is available at 20 MHz with a 115MB hard disk. The numeric coprocessor option for all models operates at the same clock rate as the respective processor.

Standard on the system board for all models except the 30 is the Video Graphics Array (VGA). It supports 640-by-480, 16-color graphics; 320-by-200, 256-color graphics; and 720-by-400, 16-color text. EGA and CGA emulations are provided. Model 30 has a subset of VGA called MultiColor Graphics Array (MCGA), which supports the 640-by-480, 2-color graphics and 320-by-200, 256-color graphics modes, as well as the EGA/CGA emulations. Four new displays are offered, each of which operates on any model.

All models feature the IBM enhanced keyboard. An IBM spokesperson said this keyboard would become universal within IBM.

A 3½-inch diskette drive is in all models. The Model 30 drive supports 720KB; the other models have a 1.44MB unit. One version of Model 30 includes two diskette drives; all other models include one diskette and one hard disk. All models come standard with five ports: keyboard, pointing device (mouse), bidirectional parallel, serial, and video.

Model 30 has three PC-compatible, 8-bit expansion slots. Model 50 provides three, and Models 60 and 80 provide seven slots for IBM's new Micro Channel bus. Model 80 has three 32-bit slots and four 16-bit slots.

Software announcements included DOS 3.3, designed to exploit many of the machines' new features, and an early announcement of Operating System/2, for the Models 50, 60, and 80, to become available in the first quarter of 1988. The standard version of OS/2 will include graphics and windowing. The extended version will include a full, relational data manager with SQL support and complete communications support.

—WF

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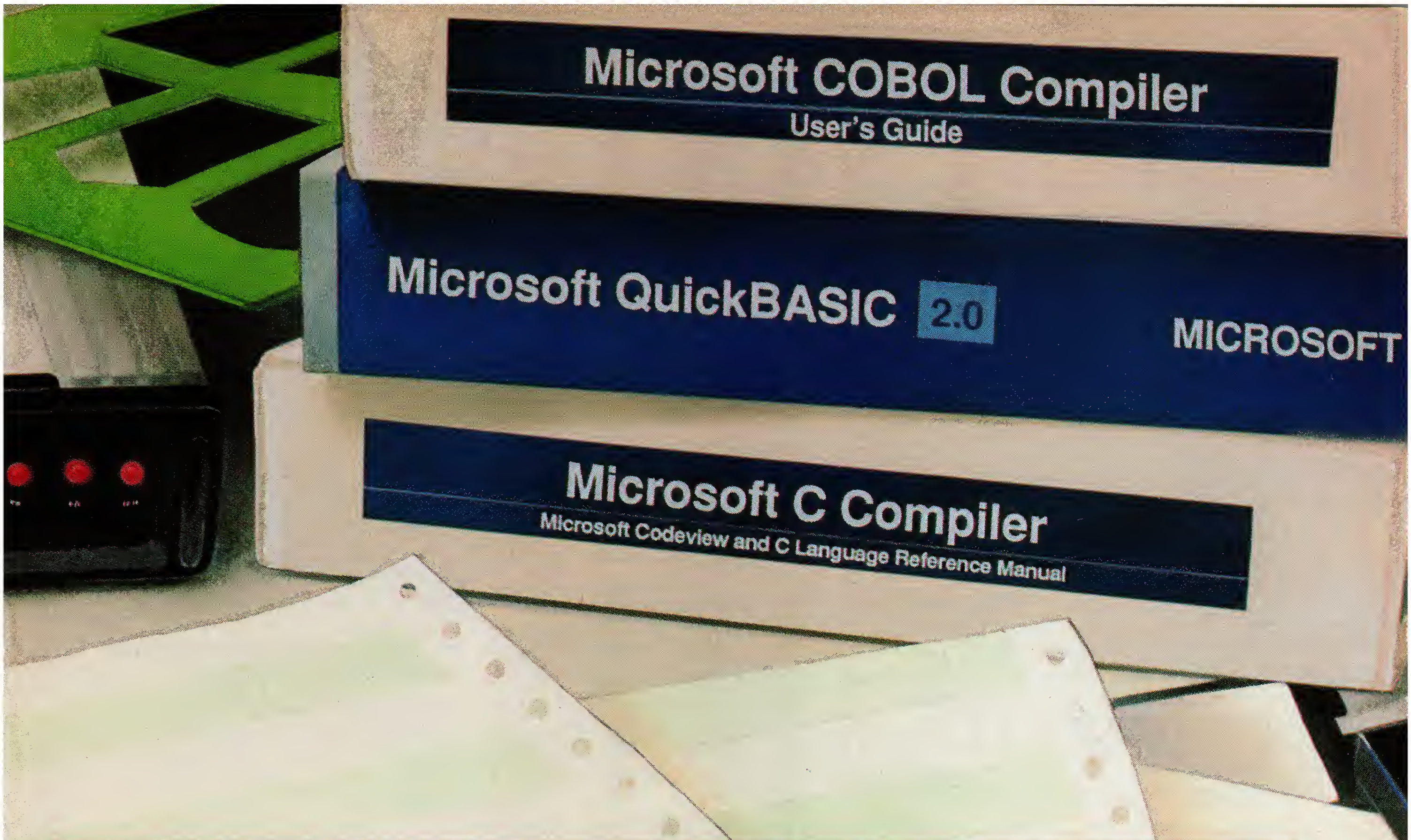

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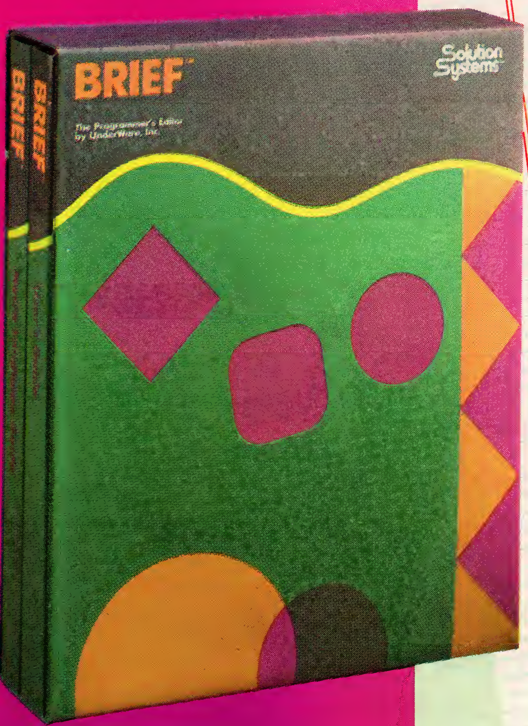

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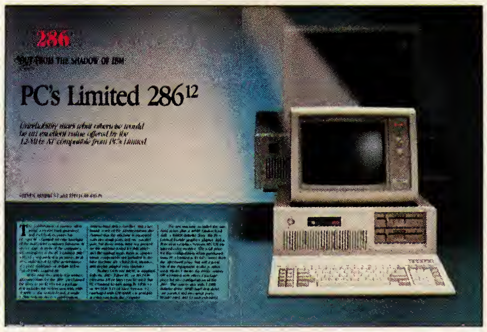
Computer Attitudes


286

PC's Limited 286¹²


Sixteen-color Graphics

LIMITED APPEAL

I am writing about your review of PC's Limited 286¹² in the February 1987 issue ("Out from the Shadow of IBM," Steven Armbrust and Ted Forgeron, p. 94). It is amazing that PC's Limited would send *PC Tech Journal* a malfunctioning machine—you can just imagine what the company sends its customers. I would be pleased to back up the authors' claims with facts, dates, and letters concerning my purchase from PC's Limited. It took months not only to get the equipment that I ordered, but also to get the machine to work correctly!

The review is quite accurate. The machine is built solidly and has nice features. I really like it, but I cannot depend on it to work 100 percent of the time. When it does work, it shows great IBM compatibility. I can run Microsoft's Flight Simulator and an IBM diagnostic diskette. But to have a problem every month and the machine inoperable while parts are shipped to Texas (lost in the warehouse), fixed, and returned is unbearable. The company is so close to doing it right that it is a real shame it doesn't just finish the job. (This is not to mention that the added expense of shipping parts back adds to the original cost of the machine, thus making IBM's high-priced units start to look almost affordable.) To be fair, the PC's Limited technical support personnel have always been courteous, and with a few exceptions, extremely helpful.

Thank you for the straightforward, tell-it-like-it-is review. We rely on that.

Michael Avila
Shawnee, KS

Regarding your February 1987 review of PC's Limited 286¹², I would like to echo some of your reviewers' complaints, and yet offer some reasons why I still laud the product and the company.

My recently purchased 286¹² also would not access the hard disk properly while operating at 12 MHz: it would not boot from the hard disk at the higher speed, and programs run from the hard disk crashed frequently. Although my first two calls to PC's Limited technical support were answered promptly by courteous personnel, they failed even to identify the problem. At this writing, my computer is somewhere between here and Texas, and I am not sure it will operate properly when I get it back. I view the first two failures by the technical support as having effectively voided my 30-day, money-back guarantee.

However, I am still happy with my purchase, and, in my job as a consultant, continue to recommend the company's products to certain clients. One reason is that with the $4,000 budget I had for my recent purchase, the PC's Limited 12-MHz $3,695 package represented the greatest value I could find, by far. More importantly, I view PC's Limited as being a symbolically important vendor in the microcomputer marketplace. Not only is it a low-cost alternative to IBM and Compaq, PC's Limited is the rare *technologically innovative* clone manufacturer, and it seems to be a very stable mail-order firm.

One of the risks of buying a clone is that the vendor may not be around to support it for very long, but this fear is minimized in buying from PC's Limited. I would like to see the company in the marketplace for years to come, and I support it by purchasing its machines, recommending them to clients and friends, and writing letters to the editors of magazines.

As an employee of a busy accounting firm, I understand the importance of deadlines and reliability, but would have sympathized more with your reviewers if they had been more mindful of the factors cited above.

A couple of minor factual exceptions to your article: the 286¹² is also available in a full-size chassis, with room for four half-height devices, and the PC's Limited sales staff does advise that only the PC's Limited memory board (1.5MB for $629) is guaranteed to work in the 286¹². Even the board's availability is omitted from the review.

Marty Nielsen
Reznick, Fedder & Silverman
Bethesda, MD

A USER-FRIENDLY OBSERVATION

Henry F. Ledgard's article "Computer Attitudes" (Expert Consultant: Human Factors, November 1986, p. 193) has prompted me to write in order to debunk two myths: the myth of the end user and the myth that the systems programmer is a hacker.

The human factors community has long had a tendency to draw an unreasonable distinction between end users, who deserve decent software, and systems operators, who should be grateful for whatever schlock software the vendor gives them. This attitude holds two very serious flaws.

The first flaw is to think that it is an easy task to determine who is an end user. It might be a paying customer on a telephone, to whom the clerk is a noisy channel with poor human factors. It might be a clerk who has easy on-line access to all relevant data, only a few of which he is permitted to give the customer. It might be a corporate travel administrator with on-line access to a ghastly reservation system. It might be a programmer going to a conference, who finds the electronic mail interface to the travel administrator to be user friendly (but has no idea of the agony it causes the administrator to process a simple request). In these and similar cases, a hierarchy of users exists, each of whom considers himself to be an end user. Which of them is entitled to good human factors? On both ethical and practical grounds, the answer should be all of them.

The second point is that, certainly, systems programmers, operators, and so on, would provide better service to the

end user, whoever he may be, if they had better tools. If the system crashes and it takes an extra 20 minutes to come back up, the end user suffers. If a new application requires an extra six months to circumvent system peculiarities, the end user suffers. If the tools for locating performance bottlenecks are really clumsy, the end user suffers.

Systems programmers use software with poor human factors because they have no choice, not because they love the challenge. The image of the systems programmer as a hacker, delighting in obscure code and unintelligible messages, is a Hollywood-style caricature. Real systems programmers want to do the best job possible, and resent tools that hinder them. They do not appreciate extracting data from a hexadecimal dump when the vendor's software should have done it for them. And they do not like having to answer "because that is how it was written" when a user asks why the software does something that is particularly unhelpful.

To listen to a few systems programmers at a user's group meeting is to hear some real anger. If they and regular users form a class "that has little conception of human factors," then why have so many resolutions come out of these very groups asking IBM to fix various human factors abominations?

The systems programmer and the regular user are more likely to know where the warts are than the casual user. If the systems programmer has experience, he will not accept the claim that an awkward syntax is "the only way it can be done," while the casual user will buy it hook, line, and sinker. Good human factors should be built into software for every level of user.

Seymour J. Metz
Annandale, VA

Many concerns are brought to bear under the collective headings of human factors and user friendliness. As Mr. Metz points out, it is sometimes difficult (and perhaps beside the point) to define who is an end user, and it is inaccurate to suggest that certain pools of users are not interested in software that offers a good human interface. The quest for universally user-friendly software will continue to require efforts in all circles—vendor and end-user alike—and has no simple or quick solution.

—WF

A FEW BYTES MISSING

I am writing about your article "Sixteen-Color Graphics" in the August 1986 issue (Programming Practices, Richard Chandler, Michael Davis, and Gary Faulkner, p. 159). The in-line Point procedure is superb. I have written it into a macro, and I am using it for a two-dimensional recurrence analysis system that needed just such a routine.

However, I must point out that the 8087 Iterate function is more than a little out of kilter. Lines 5 and 6 pull eight-byte values for *x* and *y* out of the stack, which would be just fine except Turbo Pascal reals are only six bytes long. Unfortunately, the entire module is built around the assumption that Turbo Pascal uses eight bytes for its reals, which throws everything off. For example, the iteration value

```
MOV [BP+20],CX
```

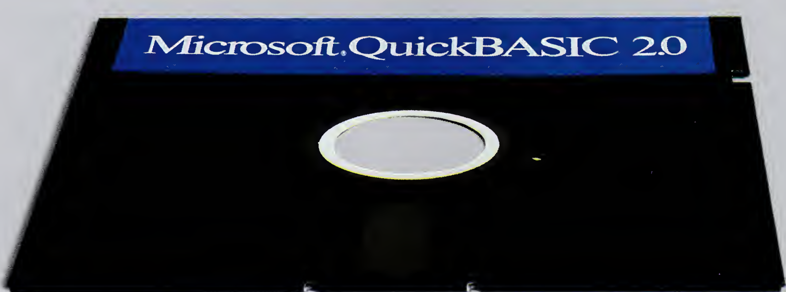
is four bytes off into never-never land, and Pascal never sees it. It should be

```
MOV [BP+16],CX
```

Of course, none of this is earth-shaking, but it occurred to me that it would be

Continued on p. 22

Microsoft is pleased to announce that Microsoft QuickBASIC 2.0 is second best.



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"(Microsoft QuickBASIC) ...represents an outstanding contribution to the microcomputer world." Dennis Dykstra, *Byte*, February 1987.*

PC Magazine was so impressed, in fact, that they gave Microsoft QuickBASIC their Technical Excellence award. Before long, Microsoft QuickBASIC 2.0 was the most award-winning BASIC compiler ever.

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"Microsoft QuickBASIC is phenomenally fast in compilation...(it) outstrips all other compilers." Marty Franz, *PC Tech Journal*, December 1986.

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Microsoft QuickBASIC makes your programming substantially faster by integrating a sophisticated editor into the compiler itself.

Any errors found during compilation trigger the editor to take over, putting your cursor right on the trouble spot.

And if you have more than one error, the editor will keep track of them all, letting you fix your bugs one after another. No more hassles with the endless recompiling of other compilers.

Divide and conquer.

Microsoft QuickBASIC gives you the power of advanced languages without the headaches. A case in point: separate compilation.

Long used in languages like C, separate compilation simply means that you can compile your programs the same way you write them, a piece at a time. Once compiled, your individual modules can be combined into libraries and added to future programs without the bother of recompiling.

But that's just one way Microsoft QuickBASIC supports structured programming.

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After all this work on improvements, we didn't forget what made Microsoft QuickBASIC the success it is. This compiler is still the leader in BASICA compatibility. From graphics to sound, this BASIC commands the PC like no other.

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The Microsoft QuickBASIC Editor is integrated with the compiler to make all your programming as fast and efficient as possible.

- ♦ Built-in editor places cursor on problem in source when error occurs in compilation.
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8087 Math Coprocessor Support.

The standard Microsoft QuickBASIC math package has been enhanced to take advantage of numeric coprocessors in machines that have them. Now you have several ways to optimize your program's performance.

- ♦ Microsoft QuickBASIC 3.0 generates fast in-line code for machines equipped with 8087 or 80287 coprocessors. Now your programs can be as fast as the hardware allows. NEW!
- ♦ Microsoft QuickBASIC includes full 80-bit IEEE Math support for programs that demand the most precise calculations possible. NEW!
- ♦ Choose from the Microsoft Binary Math routines for faster math or the new 8087 software emulation routines for more accuracy when you don't have a coprocessor.

Structured Programming Support.

In addition to the standard BASICA commands, Microsoft QuickBASIC Version 3.0 has a variety of advanced statements and features similar to those found in C and Pascal. By making structured programming easy, Microsoft QuickBASIC makes programs both easier to write and easier to maintain. Older BASIC features like line numbers and GOTO statements are strictly optional.

- ♦ New statements include SELECT CASE, DO WHILE and DO UNTIL, LOOP WHILE and LOOP UNTIL, and EXIT. NEW!
- ♦ Block IF/THEN/ELSE/END IF statements virtually eliminate any need for GOTOs.
- ♦ Subprograms may be called by name and passed parameters.
- ♦ Microsoft QuickBASIC now supports user-defined CONSTANTS. NEW!
- ♦ Both true local and global variables are supported.
- ♦ Microsoft QuickBASIC supports alphanumeric labels as well as line numbers.

Modular Programming Support.

Microsoft QuickBASIC's separate compilation lets you create stand-alone programs a piece at a time. You just compile your routines and add them to a library. Future programs can use those routines by simply linking in your libraries.

- ♦ Create stand-alone programs, with or without a separate run-time package.
- ♦ Link support routines once at beginning of a programming session, then forget about linking.
- ♦ Includes library for access to DOS and BIOS interrupts.
- ♦ Microsoft QuickBASIC makes it easy to use professional support libraries such as Softcraft's Btrieve package.

A compiler with both speed and power.

Microsoft QuickBASIC gives you the most advanced compiler features and debugging possible, without any speed handicaps. Microsoft QuickBASIC 3.0 compiles code up to an astonishing 12,000 lines per minute on an IBM® PC/AT.

Microsoft QuickBASIC also supports extra-large programs. Your programs can use all available memory for any mix of code and data. Individual arrays may use up to 64K bytes each (to the PC's limit of 640K).

BASICA Compatibility.

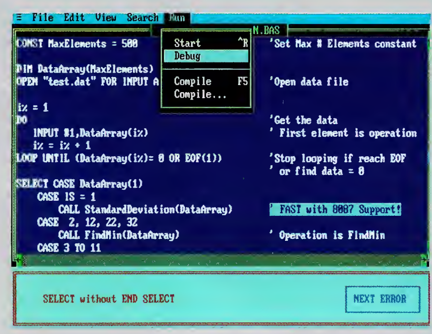
It's not hard to see why Microsoft's QuickBASIC is more compatible with IBM's BASICA than any other compiler. After all, we wrote it for IBM. And we've kept the same features in Version 3.0.

- ♦ Graphics statements include WINDOW, VIEW, DRAW, GET, PUT, LINE, CIRCLE, LOCATE, and SCREEN.
- ♦ Sound statements include SOUND and PLAY.
- ♦ Support for EGA extended graphics modes including the new 43 line mode.
- ♦ Supports standard BASICA structures such as GOSUB/RETURN, WHILE/WEND, and event handling.

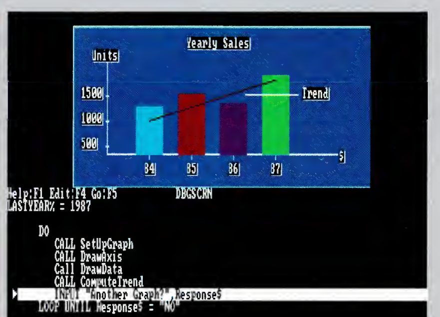
Dramatic execution speed enhancements.

Benchmark	Microsoft QuickBASIC 2.0	Microsoft QuickBASIC 3.0
Graphics (500 Circles)	21.42	9.83
Floating Point Math	16.92	6.48
Quick Sort	5.27	3.02

All test results in seconds. Tests were performed on an IBM PC/AT equipped with an 80287 coprocessor and an 8 MHz clock.



Programming is easier with the built-in editor that searches for all errors, letting you correct them and recompile without leaving the programming environment.



Pinpoint errors by tracing through your source code with the integrated debugger. You can set breakpoints and observe the contents of variables.

MICROSOFT LANGUAGES NEWSLETTER VOL. 2, NO. 5

News about the Microsoft Language Family

Writing Faster Macro Assembler Programs

Fast execution speed is probably the biggest advantage a program can have—and the Microsoft® Macro Assembler is the language of choice for writing the fastest programs. Our software engineers would like to give you a hint that can make your fast Macro Assembler programs even faster!

If you need to take the absolute value of a number held in the AX register, try this method:

```
        cwd          ; replicate the high bit into DX
        xor ax, dx   ; l's complement if negative, no change if positive
        sub ax, dx   ; AX is 2's complement if it was negative
```

The standard absolute value method works on any register but is much slower:

```
        or bx, bx    ; see if number is negative
        jge notneg   ; if it is negative
        neg bx       ; make it positive
notneg:              ; jump to here if positive
```

This fast method achieves part of its speed by avoiding the use of a jump instruction to keep the 8086's pre-fetch queue full. The 8086 always tries to fetch the next instruction from memory while it is processing the current instruction in order to save time while a program is running. A jump instruction, however, moves the location of the next instruction to fetch, making the instruction that the 8086 just fetched into its pre-fetch queue invalid. This forces the 8086 to spend time fetching the correct instruction from memory after the jump. Whenever possible, avoiding jumps will increase the execution speed of your Microsoft Macro Assembler programs.

New Microsoft COBOL Version Includes Symbolic Debugger, Cross-reference Generator, and Other Utilities

Microsoft COBOL Compiler Version 2.2 now includes COBOL Tools which was formerly sold as a separate package at a suggested retail price of $350. This powerful set of productivity aids minimizes coding time and reduces the cost of program development and maintenance. Both the MS-DOS® and XENIX® 286 versions of the compiler packages have been updated. Microsoft COBOL now includes ViewCob, the most intuitive, interactive symbolic debugger for COBOL on the market; CobRef, an advanced cross-reference generator; Menu Handler, an innovative utility to enhance your Microsoft COBOL applications with a menu-oriented user interface; and CbMouse (only in the MS-DOS version), an object module to interface the Microsoft Mouse to your applications.

ViewCob has an easy-to-learn, menu-driven interface similar to that of Microsoft Multiplan® It supports multiple windows for viewing source code, program execution history, breakpoints, and memory locations while your program is executing. Powerful execution control, breakpoints, and tracing provide the programmer with a tool for analyzing all aspects of a Microsoft COBOL program. Modify any data-item at any breakpoint to test different conditions in your program without cumbersome data input or recompilation. Trap runtime errors. In some cases (e.g., non-numeric data), you can correct the situation and continue execution. On-line help messages are available for descriptions of command functions and general operational procedures.

CobRef allows the COBOL programmer to cross-reference source code listings to data-items, files and procedure calls in a program. In addition to name and type, listings include details on where an item is defined and referenced.

Menu Handler provides a program skeleton for creating applications with a menu-oriented user interface that is similar to the interface for the popular Microsoft Multiplan. Entries in the command area are mapped to the procedure calls in your Microsoft COBOL application.

CbMouse object module is linked to the program runtime. It translates the COMP-O data-items defined by the programmer into the format that the mouse system calls are expecting. It converts the pixel values needed by the Microsoft Mouse to row/column values used by COBOL without the application needing to go through the conversions.

For more information on the products and features discussed in the Newsletter,
write to: Microsoft Languages Newsletter
16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717.
Or phone:
(800) 426-9400. In Washington State and Alaska, call (206) 882-8088. In Canada, call (416) 673-7638.

Latest DOS Versions:

Microsoft C Compiler	4.00
Microsoft COBOL	2.20
Microsoft FORTRAN	4.00
Microsoft Macro Assembler	4.00
Microsoft Pascal	3.32
Microsoft QuickBASIC	2.01

helpful to know a way in which to interface Turbo reals to 8087 long reals without a lot of cumbersome masking and shifting. Any suggestions?

Michael H. Glenn
New York, NY

The problem Mr. Glenn experienced is caused (as he indicated) by the incompatibility between the floating-point formats used by Turbo Pascal and the 8087. The numeric coprocessor (as we used it) requires an eight-byte real and Turbo Pascal uses a six-byte real. One could write a routine to translate one to the other, but the best solution is to obtain a copy of TURBO-87.COM, Borland's version of Turbo Pascal for 8087-equipped PCs. We were remiss for not reminding users of this fact.
—Richard Chandler and Gary Faulkner

THE RIGHT TYPE OF PROLOG

In a letter that was published in your February 1987 issue ("Pro Turbo," Letters, p. 17), Philippe Kahn says that the required data typing in Borland's Turbo Prolog is an improvement over the untyped Prolog syntax commonly referred to as the Edinburgh or Clocksin-and-Mellish standard. Mr. Kahn's opinion bears some careful examination.

The underlying purpose for declaring the data types of variables in traditional, structured languages is to tell the compiler what space and storage class to allocate to the variables in question. A secondary purpose espoused by some educators is to teach students clear, organized thinking, and to demonstrate issues involved in data typing. However, once those issues have been learned, most professional programmers migrate to some less restrictive language, such as C, in which data typing serves the purpose of storage-class allocation. In and of itself, data typing is not a "good" thing, but rather is a reality of structured, algorithmic programming.

Prolog, however, was not conceived to be yet another structured language. Instead, Prolog embodies the principles of deductive logic in a simple and elegant syntax comprised of facts, rules, and lists. The reason that data typing was not designed into Prolog was neither accidental, nor an expression of some innate laziness on the part of the many fine workers who have contributed to Prolog's design.

In fact, most Prolog implementations are either interpreters or pseudocode compilers with an interpretive kernel for a reason—to preserve untyped syntax. Actually, calling Edinburgh-syntax Prolog an interpreter is an oversimplification, since even simple Prologs are incremental compilers, capable of both runtime compilation and disassembly of self-asserted code, making possible the tiered logic of true Prolog programming—programs that can ponder, learn, and make assertions.

Thus, Mr. Kahn's opinion notwithstanding, it has been seen as a design advantage for Prolog programs to have the ability to compare, equate, and associate atoms and variables without regard to either their physical storage within the host machine or to their logical origin within the program. Only with this degree of flexibility can programs in Prolog have such powerful constructs as the same predicate defined with different arities, or lists of varied object types. Such lists may be slower to traverse than the arrays that pass for lists in Turbo Prolog, but they are nonetheless more reflective of the complex associative lists that we humans build in our own thinking.

Mr. Kahn asks why anyone would want to write self-modifying Prolog programs. I have a partial answer.

It has been central to the challenge of AI programming to consider the underlying unities of objects when viewed from different frames of reference. We observe that a 4-year-old child can recognize a fundamental association between a tiger in a zoo and a domestic cat; yet, for computers, it has been difficult, if not impossible, to write programs capable of similar intuitiveness.

Turbo Prolog would have us define *tiger* and *tabby* as being of type *cat*, but this is a sterile approach since we have been forced to build into the program's assumptions the deduction that will be arrived at—that tabbies and tigers are both cats. In standard Prolog, such unifications are made by the program, and often come as a surprise, with an accompanying insight into the knowledge base. In Turbo, they are definitional. A Prolog that cannot recognize the simple unification of "catness" without the crutch of data typing will suffer the same limitations when analyzing the stock market or diagnosing disease.

For Mr. Kahn to say that Prolog was "developed in universities for universities, a situation in which ease of programming comes first and programs are typically not run more than once," does a rude disservice to many fine Prolog programmers whose academic research and pragmatic problem solving in the realm of business software contributed greatly to the AI literature since 1972.

As with any computer language, Prolog was developed to solve specific programming challenges. Its success in meeting these challenges—without data typing—for more than a decade, is a testament to the soundness of standard Prolog's core idea: that principles of logical unification, regardless of physical data storage class, can be used to drive computer processing.

Lan Barnes, president
Chalcedony Software, Inc.
La Jolla, CA

READING BETWEEN THE LINES

I strongly disagree with John Myrna's article on the IBM Proprinter XL in the November 1986 issue (Product Watch, p. 187). I tried three different machines in one week, and all of them have printed the same way—producing a thin horizontal blank line through every third or fourth line of text. *(Editor's note: The letter submitted by this reader, printed on the Proprinter XL, provided substantial evidence of the problem.)*

This letter was produced using the Microsoft Windows Write program—indeed, it was in using this program that the problem first appeared. The little white lines that run through the text do not occur there by accident or because anything is wrong with the paper, program, or computer. They are designed into the Proprinter XL.

When the first two new machines exhibited the same problem, I took them back in turn to the dealer and demanded an exchange. Upon this third machine's producing the same result, I did some investigation to determine the cause. After some electronics checks, I did several hex dumps and determined that the printer was not receiving scrambled data, nor noise from any source. I then did a mechanical check and found that the gear train that drives the paper feed mechanism has far too much backlash. Further, this gear train is so badly designed that every unit will develop this problem sooner or later. To demonstrate this, it is necessary only to pull forward slightly on the paper coming out of the printer, and the lines will disappear. To make them appear at regular intervals, pull back slightly on the paper going into the machine. If the paper is allowed free travel, the lines appear randomly, and the space can be as much as 1/32-inch wide.

In my tests, this problem appears only in running a program that outputs graphics, even though the normal CR and LF are used at the end of each line. But using special typographers' measuring glasses, you can determine that the line spacing in text mode varies, indicating the same problem.

I plan to return this unit as well, in exchange for a new Epson LQ-2500. I have decided to stay with a real winner, as IBM should have done. My MX-100 with graphtrax, is more that 5 years old, and plugs along daily, doing a far better job than this new machine. I think IBM had good ideas with the Proprinter XL, but its implementation fell short.

Bruce D. Anderson
BRAND Consultants
Brattleboro, VT

The machine reviewed by PC Tech Journal *did not exhibit this problem, but it was not run with Windows Write. When we notified IBM engineers of this problem (in December), they said it was the first occurrence of which they were aware. They researched the problem, were able to reproduce it, and suggest that it happens on "certain machines running certain software." (The com-*

pany is aware that the gear train has backlash—the microcode in the printer was written to handle it.) The IBM staff working to correct the problem says that an engineering fix should be available from IBM service representatives by the time this letter is printed.

—John Myrna

MESSAGE RECEIVED

We at Quantum Software Systems Ltd. wish to compliment *PC Tech Journal* for the excellent article, "Realtime Systems: A Message-Passing Executive," which was a review of the QNX operating system (Gary Elfring, January 1987, p. 126). The author displays an uncommon depth of research and understanding of this very technical subject.

We find it inappropriate, however, that the speed of QNX was compared exclusively to that of realtime executives. QNX is an operating system and not an executive. If stripped down to just the kernel, QNX would have the same capabilities as a realtime executive. Furthermore, the kernel would have a task-switching speed of 1 to 2 milliseconds, certainly on a par with any other realtime executive.

Since the article was published, task-switching speeds have been upgraded (on an 8-MHz PC/AT) running in real mode and protected mode to 350 microseconds and 450 microseconds, respectively. For realtime applications, however, a more critical measure of speed is response time to interrupts. In the best case on a PC, interrupt handling by QNX is virtually instantaneous; in the worst case, it is 1 millisecond. The worst-case response time on an AT is 300 microseconds.

Nonetheless, QNX is more than an executive. Along with realtime capabilities, QNX provides complete file system ability and device support. It thus qualifies as a full operating system.

While Mr. Elfring is to be commended for the depth and accuracy of his review, the following clarifies and/or updates a number of important points:

In QNX, if tasks are local (in the same machine), the user can pass pointers to the message and not the message itself. Furthermore, it takes only about 500 nanoseconds to transfer one word on an AT; therefore, QNX is not as slow as Mr. Elfring implies.

Contrary to Mr. Elfring's implication that it requires an AT, the DOS emulation runs on the PC, PC/XT, PC/AT, and compatibles. DOS emulation on the AT in protected mode is supported only by the AT and the Compaq Deskpro 286, as the author notes.

It is not necessary to run administrators at a higher priority than any task that uses that administrator, although this is the usual case. In addition, user tasks can now run at priorities 3 and 2; however, they cannot run at priority 1.

On each microcomputer, QNX supports 13 devices, of which 4 can be full-screen windows (virtual terminals). In addition to shared libraries, if the same program is run more than once, its code is shared. This is important where the same control task may be running more than once, but handling different devices. Note also that the user now can unmount shared libraries.

Although it is not difficult to write a custom administrator with a message-passing interface to perform the record-locking actions required by an application, Quantum has just released a QNX administrator called LOCKER. The QNX implementation of record locking follows AT&T System V Interface Definition and the /usr/group standards. Applications written to these standards may be ported easily to QNX.

Quantum does not provide Pascal or FORTRAN compilers, although it is currently negotiating a FORTRAN port.

The actual options available to a task when it creates a child are as follows: (1) It may wait upon the child's death before continuing to execute. (2) It may continue executing in parallel with the child (concurrent). (3) It may continue to execute in parallel but not preserve the parent-child relationship (background). In this particular case, the death of the parent task will not kill the new child task.

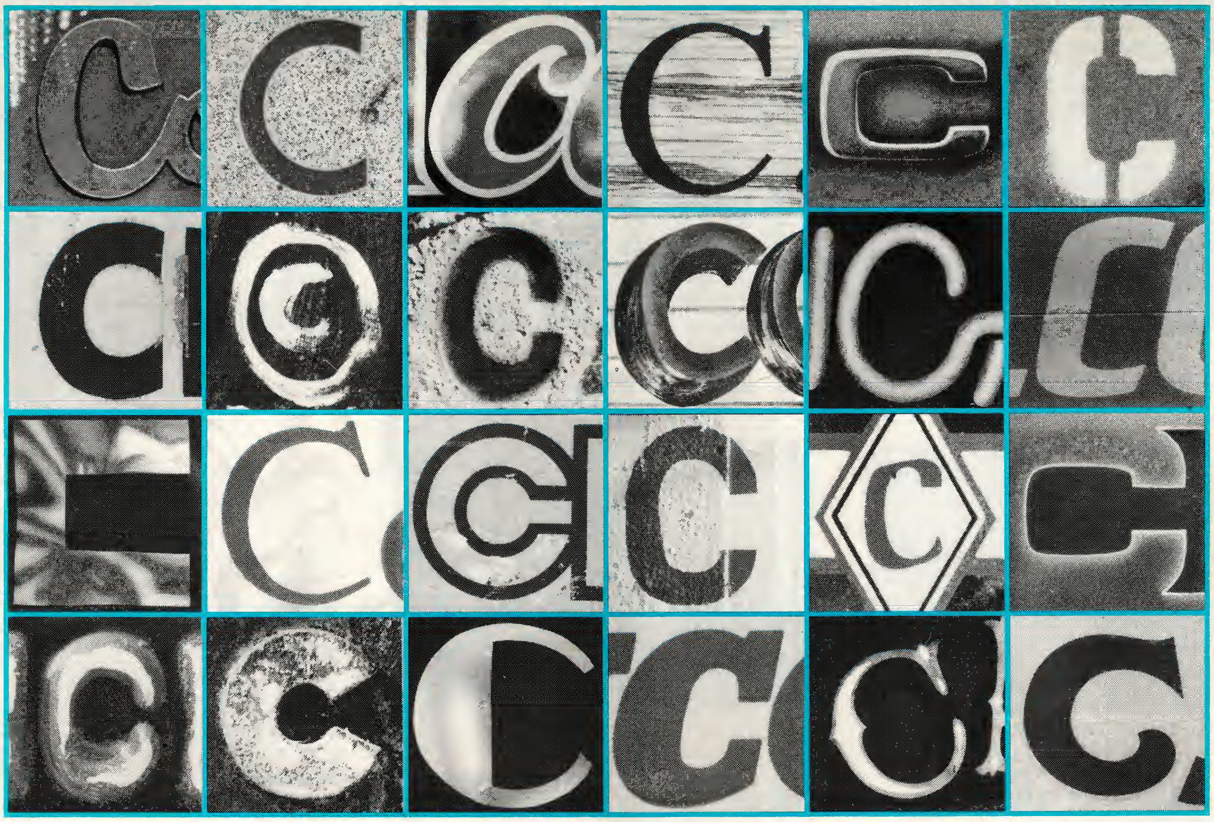
Finally, while QNX excels at networked realtime control that involves databases, this system is equally well-suited to other situations, including process control applications on stand-alone microcomputers and office automation applications in which integrated networking (providing multiuser, distributed processing, distributed programs and data, and full resource-sharing capabilities) is required.

Again, we offer many thanks to *PC Tech Journal* for the quality and integrity of its journalism.

Jan Scheeren
Quantum Software Systems Ltd.

IN GOOD FORM

The figure showing form factors for hard-disk cards (figure 1 on p. 78 of "Mass-Storage Mergers," Peter G. Aitken, January 1987, p. 76) was simply excel-



lent. I have had difficulties fitting these cards into the computer, and your chart should greatly simplify matters.

Warren W. Munro
Aiea, HI

A BRIEF RETRIEVE

PC Tech Journal has published articles on retrieving the program environment (as established by the DOS SET command) and on retrieving arguments from the program command line from Pascal. I have no problem with retrieving these parameters from assembly language programs, but I was not able to call these subroutines from Microsoft FORTRAN. I would appreciate suggestions on how to solve this problem.

David J. Krus
Arizona State University
Tempe, AZ

This month's Programming Practices ("Command-Line Arguments for FORTRAN," John W. Ross, p. 190) describes a means of retrieving command-line arguments from Microsoft FORTRAN.

—JS

ERRATA

In "Compatibility and Performance: The New Standard" (Steven Armbrust and Ted Forgeron, March 1987, p. 48), in table 3 on page 66, the percentage figure for the ATFLOAT test for the Compaq Deskpro 386 should read 170 instead of 107. In addition, the tint legend at the bottom right of figure 5 (on page 67) is reversed. The "Deskpro 386, within 2KB page" should be indicated as the darker tint. These keys for the Deskpro 386 will be constant throughout the compatibility series. They are correct in figure 1 (on page 126) of "Compatibility and Performance: Poised for Tomorrow" on the ALR Access 386 (Michael Abrash and Dan Illowsky, April 1987, p. 104).

COMMENT AT WILL

All letters to the editor should be directed to Editor, *PC Tech Journal*, Suite 800, 10480 Little Patuxent Parkway, Columbia, MD 21044. Correspondence also can be submitted over MCI Mail to PCTECH.

Although *PC Tech Journal* cannot publish every letter received, every effort is made to answer as many as possible. Please keep letters brief and to the point, and include name, mailing address, and telephone number; when a letter is lengthy, a diskette is appreciated.

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Whetstone	53.82	58.67	79.04
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C Benchmarks

In seconds

	Microsoft C 4.0	Lattice C 3.0	Computer Innovation C 2.3	Aztec C86 3.2	Wizard C 3.0
Sieve of Eratosthenes (register)	82.9	151.4	172.3	88.0	91.9
Copy Block	86.9	231.7	199.0	123.8	189.5

Run on an IBM PC XT with 512K memory

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- Watch CPU registers and flags as you execute.
- Effectively uses up to four windows.
- Debug using your original source code, the resulting disassembly or both intermingled.
- Use drop-down menus to execute CodeView commands.
- Access the on-line help to lead you through CodeView's options and settings.
- Easily debug graphics-oriented programs since program output is kept separate from debugger output.
- Keyboard or optional mouse support.
- Enter in familiar SYMDEB or DEBUG commands.

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you've ever seen.

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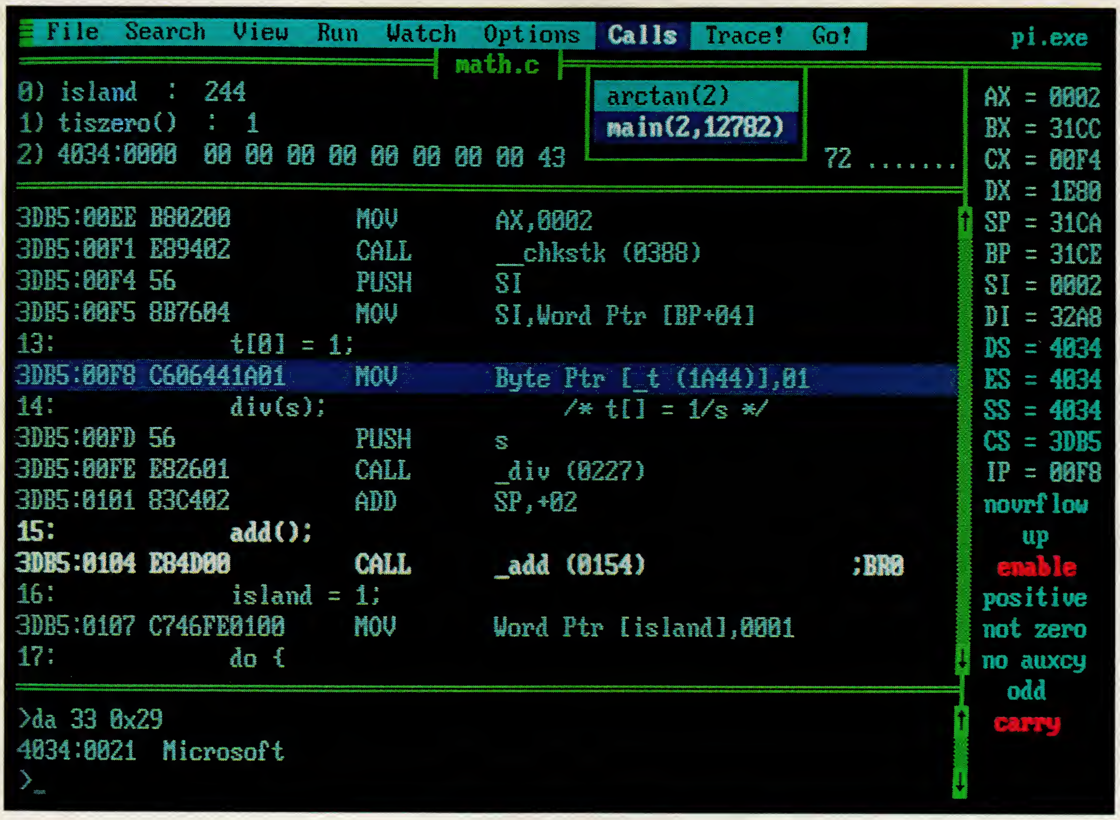

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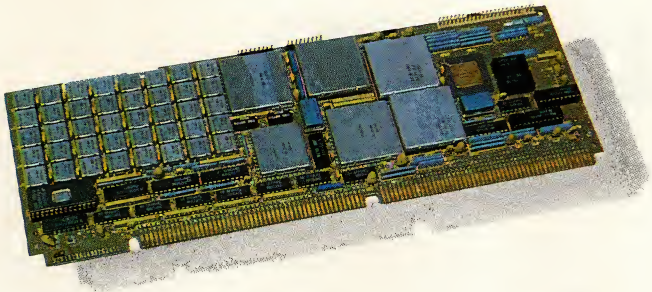
The High Performance Software

Hardware, software, and other developments for the IBM PC family



Advanced Processor Card for the upgraded IBM RT PC

IBM PC Convertible with enhanced LCD screen

FROM IBM

Three enhanced, 32-bit models of the **RT PC** have been developed by **IBM Corporation**. Based on IBM's reduced instruction set computer (RISC) architecture, the desktop **6151 model 115** and two floor-standing units, the **6150 model 125** and **6150 model B25**, feature the Advanced Processor Card (APC), which contains a higher performance CMOS processor, built-in 20-MHz floating-point circuitry, and 4MB of fast CMOS memory.

Each RT comes with a 1.2MB diskette drive and a 70MB hard-disk drive. Models 125 and B25 can accommodate up to two additional 70MB hard disks and have a larger power supply and more expansion slots than model 115. The microprocessor uses the RISC architecture and operates at 100 nanoseconds (ns) per instruction, compared with 170 ns for the previous processor. These RT models also feature a memory management unit (MMU) that allows the user to access up to 1 trillion characters of virtual memory.

The **Extended Enhanced Small Device Interface (ESDI) Magnetic Media Adapter** has an improved transfer rate and the ability to accommodate three internal hard-disk files. The RT's Advanced Interactive Executive (AIX) has been enhanced to support these models, an assortment of peripherals, and expanded communications capabilities, such as the IBM Token-Ring LAN and the Ethernet LAN.

In addition, graphics capabilities have been improved with the introduction of an adapter that permits direct attachment of high-resolution monitors that can function both as application displays and RT operator consoles. The **Megapel Display Adapter** has a resolution of 1,024 by 1,024 pixels with a choice of 256 colors from a palette of 4,096, or 16 shades of gray on monochrome. A 19-inch monochrome display, the **Moniterm VY-6155**, features a resolution of 1,024 by 768 pixels. RT PC 6151 model 115, $10,600; 6150 model 125, $16,100; 6150 model B25, $17,670; upgrade kit, $2,495; 4MB fast-memory expansion, $3,800; 8MB; $5,000; Megapel display adapter, $4,500; 70MB extended ESDI/hard-disk drive, $2,395; Moniterm VY-6155 monitor, $1,395.

The performance of the PC Convertible has been expanded with several announcements from IBM. An **Enhanced Liquid Crystal Display** (LCD) features greater contrast and readability and has a wider viewing angle and an etched glass screen surface for reduced glare. The enhanced display uses the supertwist technology in which liquid crystal molecular chains are highly twisted, causing light waves to bend and produce darker characters. An **Enhanced Internal Modem** gives users support for communications applications that use either the IBM or ATtention (Hayes) command set. The **256KB Memory Card** expands user memory to 640KB. PC Convertible with enhanced LCD, $1,995; enhanced LCD, $250; enhanced internal modem, $450; 256KB memory card, $390.

IBM Corporation, 900 King Street, Rye Brook, NY 10573; 800/426-2468

CIRCLE 301 ON READER SERVICE CARD

HARDWARE

A 20-MHz version of the 80386, the **80386-20**, has been released by **Intel Corporation**. The 80386-20 operates at 4 to 5 million instructions per second (MIPS), a 25-percent increase in processing speed over the 16-MHz version.

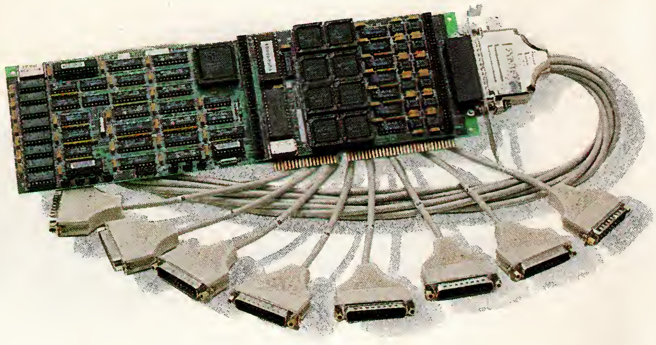
Also announced was the availability of a single-chip, 32-bit numeric coprocessor for the 80386. The **80387** is object-code compatible with the previous generations of coprocessors, the 8087 and 80287. The 80387 is optimized to provide the highest possible floating-point performance and directly extends the 80386 instruction set to include trigonometric, logarithmic, exponential, and arithmetic instructions. Prices are based on quantities of 100. 80386-20, $599; 80387, $500.

Intel Corporation, Literature Department W351, P.O. Box 58065, Santa Clara, CA 95052-9979; 800/548-4725

CIRCLE 303 ON READER SERVICE CARD

A highly integrated 32-bit device that combines direct memory access (DMA) control and major processor support functions to increase the performance of 80386-based microcomputers has been introduced by **Intel**. The **82380 Integrated System Peripheral** (ISP) incorporates a DMA controller that is capable of using the entire 32-bit bus bandwidth of the 80386 via eight independently programmable channels. Two versions of the ISP are available: the 82380-16, which operates at 16 MHz, and the 82380-20, which operates at 20 MHz. Peripheral functions that are integrated onto the chip include a 20-level programmable interrupt controller (a superset of Intel's 82C59), four 16-bit programmable interval timers (a superset of Intel's 82C54), a programmable wait-state generator, a dynamic RAM (DRAM) refresh controller, and system reset control logic.

Intel also has announced its development of a high-performance, 32-bit cache control device that improves system performance by allowing an 80386-based microcomputer to realize the full potential of the CPU. The **82385 Cache Controller** eliminates processor wait states and reduces the bus accesses to main memory. The 82385 can cache or store 32KB of the most frequently used code and data from the full 80386 physical address range of 4GB. Its bus-watching logic ensures that the cache memory contains an up-to-date copy of the main memory. Prices are based on quantities

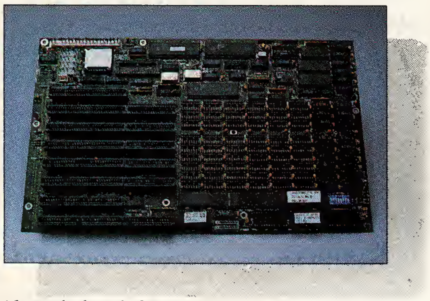


DigiBoard COM/8i asynchronous serial port board with cables

AST 5250-Premium/286 workstation from AST Research

of 100. 82380-16, $149; 82380-20, $299. Prices on the 82385 are not available.
Intel Corporation, Literature Department W350, P.O. Box 58065, Santa Clara, CA 95052-9979; 800/548-4725
CIRCLE 304 ON READER SERVICE CARD

The introduction of the **12-MHz Compaq Deskpro 286** has been announced by **Compaq Computer Corporation**. This desktop model replaces the original 8-MHz Deskpro 286. It features 100-nanosecond dynamic RAM (DRAM), as much as 80MB of high-performance hard-disk storage with average access times of under 30 milliseconds, and an optional internal 40MB hard-disk tape backup. Total system memory can be expanded to 8.1MB. A dual-speed processor allows the user to switch between 12 MHz and 8 MHz. The expansion bus operates at 8 MHz while the processor runs at 12 MHz, maintaining



The motherboard of the 12-MHz Compaq Deskpro 286

compatibility with the most expansion boards created for 8-MHz, 80286-based systems. The Deskpro 286 comes in three standard configurations. **Model 1** has 256KB of RAM, a socket for an 80287 numeric coprocessor, a 1.2MB diskette drive, seven available expansion slots (five 8/16-bit and two 8-bit), a 101-key enhanced keyboard, an upgraded 192-watt steady-state power supply, a parallel printer interface, an asynchronous communications interface, a realtime clock, and a security lock. **Model 20** is the same as model 1, but with 640KB of RAM and a 20MB hard disk. **Model 40** is the same as model 20, but with a 40MB hard disk. Model 1, $2,999; model 20, $3,999; model 40, $4,999; 512KB memory option kit, $199; 512KB/2,048KB memory expansion board, $475; half-height 20MB hard disk, $1,399; 40MB, $2,199; full-height 70MB, $3,999; 360KB diskette drive, $225; 1.2MB diskette drive, $275; 8-MHz 80287, $349; color monitor, $799; dual-mode monitor (amber or green), $255; enhanced color graphics board, $599; video display controller board, $199; 40MB hard-disk backup tape drive, $799.
Compaq Computer Corporation, 20555 FM149, Houston, TX 77070; 713/370-0670
CIRCLE 345 ON READER SERVICE CARD

DigiBoard, Inc. has released the **DigiBoard COM/4i** and **COM/8i** communication port boards (with four and eight asynchronous serial ports, respectively) that feature an on-board coprocessor. These boards provide processing speeds up to four times faster than existing multichannel boards. They incorporate a modular I/O design with the I/O contained on a daughterboard mounted on the host board. The host board utilizes a 10-MHz 80188 and 256KB of dual-ported RAM. The four- and eight-port RS-232 asynchronous daughterboard design allows flexibility in terms of I/O configuration and customization. The COMWARE software that comes with the boards includes a DOS device driver that allows the system to access up to 8 ports per board, for a total of 32 ports per system. All of the necessary cables are included. COM/4i, $969; COM/8i, $1,195.
DigiBoard, Inc., 6751 Oxford Street, St. Louis Park, MN 55426; 800/344-4273; in Minnesota, 612/922-8055
CIRCLE 316 ON READER SERVICE CARD

A complete workstation based on the 6/8/10-MHz Premium/286 PC with extensive IBM 5250 terminal-emulation features is being offered by **AST Research, Inc.** Along with the 5250 emulation capabilities, the **AST 5250-Premium/286** features an advanced bus architecture that operates with zero wait states, complete IBM compatibility for extensive software support, and conflict-free hardware connection. The 5250 emulation includes all 32 of the 5251 model 11 display and field attributes and up to seven simultaneous System/34/36/38 sessions. The system can emulate a variety of IBM display terminals, including 5251 model 11, 5291, 5292 model 1, or 5251 model 12.

PC-attached printers, such as AST's TurboLaser, can function as IBM 5256, 5224, 5225, and 5219 printers. With the 5250-Premium/286, all attached PCs that incorporate cluster nodes, asynchronous dial-up connectors, or gateway capability, can share the attached PC printers as 5250 printers. The included bidirectional file-transfer software eliminates rekeying errors and enables manipulation of System/3x data, using PC applications software. In addition, IBM's FSU, PC Support 36 and 38, and IBM-compatible Applications Program Interface (API) software can be run on the workstation. The AST 5250-Premium/286 with 80286 CPU, 1.2MB diskette drive, 101-key keyboard, AST-5250/Display adapter (with Hercules bit-mapped graphics caability), AST Premium Display/Monochrome, and AST 5250/11 Plus (twin-axial emulation), $3,095; and with added internal 20MB hard-disk drive, $3,595.
AST Research, Inc., 2121 Alton Avenue, Irvine, CA 92714; 714/863-1333
CIRCLE 305 ON READER SERVICE CARD

Chips and Technologies, Inc. (C&T) has enhanced its **STARLAN 82C550A** serial interface chip. Features of the 82C550A provide support for bus implementations and help ensure greater reliability and efficiency of the entire network. Enhancements include a watchdog timer to truncate transmissions of

PC4100 13-inch color monitor from Tektronix, Inc.

Paradise AutoSwitch EGA 480 from Paradise Systems

unusual length, an enhanced filer to detect carrier sense signals, and an improved phase-locked loop circuit to guarantee ±90-nanosecond jitter tolerance. Implemented in a 20-pin plastic DIP, the 82C550A replaces as many as 60 of the devices used in current STARLAN implementations. The chip conforms to IEEE 802.3 STARLAN specifications and is compatible with the Intel 82586 LAN coprocessor serial interface. Price for quantity of 100, $9.50.
Chips and Technologies, Inc., 521 Cottonwood Drive, Milpitas, CA 95035; 408/434-0600
CIRCLE 306 ON READER SERVICE CARD

A high-performance coprocessor graphics board from **Dolen Computer Corporation** can display 16 colors at high resolution (800 by 600 pixels). Primarily designed for use in conjunction with high-performance monitors, such as the NEC Multisync or Sony MultiScan, the **MultiVID 16** also can be used with IBM EGA-compatible monitors, boosting their display to 16 colors with a resolution of 640 by 480 pixels. $699.
Dolen Computer Corporation, P.O. Box 599, Norwalk, CT 06856; 203/855-0895
CIRCLE 311 ON READER SERVICE CARD

Shipment has begun of the **Paradise AutoSwitch EGA 480** from **Paradise Systems, Inc.** The EGA 480 is a video display adapter that renders selected EGA applications in high resolution (640 by 480 pixels) and 132-column modes on multifrequency monitors. This board automatically detects the type of monitor used and switches between different video modes (IBM EGA, CGA, monochrome display, and the Hercules graphics card). Paradise Systems uses its PEGA 2 enhanced graphics chip and software drivers. $599.
Paradise Systems, Inc., 217 E. Grand Avenue, South San Francisco, CA 94080; 415/588-6000
CIRCLE 309 ON READER SERVICE CARD

A PC/AT-compatible motherboard, the **ZEOS 386/M** by **ZEOS International**, upgrades the PC, PC/XT, and PC/AT to full-fledged 80386-based systems. The ZEOS 386/M features a 16-bit, AT-compatible bus for peripherals and a 32-bit, 16-MHz, zero-wait-state bus for memory. Support for the Intel 80386 is provided by the Chips and Technologies (C&T) seven-chip AT/386 VLSI (very large scale integration) chip set combined with C&T's 82C206 integrated peripheral controller (IPC). Sockets on the motherboard are provided for several options: C&T's two-chip, enhanced graphics adapter set; Western Digital's single-chip, diskette-drive controller; two serial ports, and one parallel port. Included with the board is a Phoenix 80386 AT-compatible ROM BIOS that is compatible with DOS 3.2 and later. A socket for the 80387 is provided. The board has provisions for up to 16MB of memory of fast zero-wait-state dynamic RAM (DRAM), and a minimum of 1MB of system memory is required. The PC 386/M has four 16-bit slots; the XT 386/M has three 16-bit and two 8-bit slots; the AT 386/M has four 16-bit and three 32-bit slots. Without memory, $1,995.
ZEOS International, 530 Fifth Avenue NW, Suite 1000, St. Paul, MN 55112; 800/423-5891; in Minnesota, 612/633-4591
CIRCLE 308 ON READER SERVICE CARD

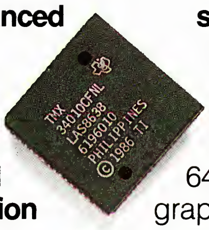
A family of 19-inch **VARI-SCAN** color monitors has been developed by **Electrohome Limited**. The **ECM 1910**, **1911**, and **1912** feature automatic horizontal and vertical frequency adjustments. The horizontal adjustment (15 KHz to 34 KHz) allows the monitor to interface to a PC using any one of a variety of add-on color graphics cards, such as the IBM CGA, EGA, and PGC, as well as those by Conographics, Tecmar, and Persyst. The vertical adjustment (50 Hz to 85 Hz) allows the monitor to automatically center. The ECM 1910 has short-persistence phosphor with a tinted, glare-reducing CRT, which delivers a bright, high-contrast display for use in high-ambient-light environments. The ECM 1911 has a high-contrast display that remains flicker-free due to the long-persistence CRT phosphor used. The ECM 1912 is for use in bright environments; it has a clear CRT with the long-persistence phosphor. The resolution is 1,024 by 512 pixels (noninterlaced) and 1,024 by 800 (interlaced). ECM VARI-SCAN monitors, $3,195 each.
Electrohome Limited, 809 Wellington Street N, Kitchener, Ontario, Canada N2G 4J6; 519/744-7111
CIRCLE 313 ON READER SERVICE CARD

A family of advanced computer graphics products is available from **Tektronix, Inc.** The products include the **PC4100 graphics coprocessor board**, the 13-inch **PC4100 color monitor**, and two software packages, **PLOT 10 PC-05** and **PLOT 10 PC-07**, that emulate the Tektronix 4105 and 4107 terminals. These products are compatible with the Tektronix 4696 Color Ink-Jet Printer. The PC4100 graphics board provides resolution up to 640 by 480 pixels and features 256 simultaneous colors from a palette of more than 16 million. The board is compatible with the IBM EGA and CGA. The PC4100 incorporates the Texas Instruments TMS34010 graphics system processor chip for fast throughput of high-level graphics functions. The coprocessor has two memory banks on its board. The first is its display memory, also known as the frame buffer, the second is 1MB of general-purpose RAM. The megabyte of RAM can be used to store graphics images in pixel or display-list form for high-performance drawing. The PLOT 10 PC-07 provides advanced Tektronix Graphics features, such as segments, true zoom and pan, view ports, and DEC VT-100 compatibility. The PLOT 10 PC-05 adds selected 4105 graphics terminal capabilities to a

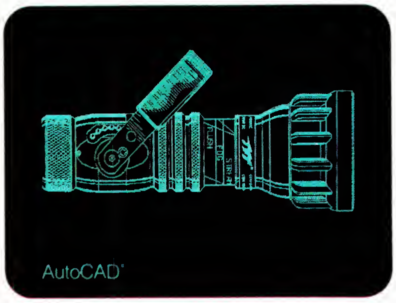

TEKTRONIX NEW
ADVANCED PC GRAPHICS
STANDS ALONE.
AERODYNAMIC HEATING
EQUILIBRIUM TEMPERATURE
CONE SECTION
CYLINDRICAL SECTION
TEMPERATURE
DISTANCE
TIME

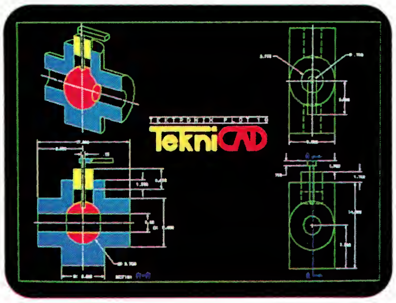
BECAUSE IT WORKS TOGETHER.

Introducing Tek Advanced PC Graphics: a fully integrated system of high-performance graphics, easy system connectivity, and unparalleled application software for your PC. Tek Advanced PC Graphics starts with a flexible multiple-rate color graphics monitor that provides 640x480 Tektronix-style graphics as well as EGA and CGA software compatibility.



Driving your monitor to a whole new level of graphics speed is Tek's PC4100 graphics coprocessor board. It features Texas Instruments® powerful TMS 34010 32-bit



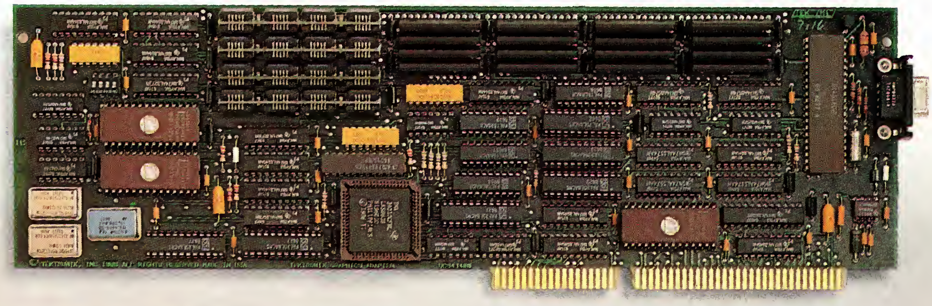


Graphics System Processor for ultra-fast throughput of your design applications. Add to that Tek's PC-05 or PC-07 terminal emulation software, and you're ready for stand-alone computing or access to a world of mainframe graphics.

To bring those applications to life, you can connect a Tek color ink-jet printer. And start producing high-resolution, vibrant hardcopy output on either paper or transparencies.

Couple all that with Tektronix worldwide support and service, and your PC can gain the same productive advantages that host-based systems in scientific and engineering environments have had for close to two decades.

Tek's PC4100 graphics coprocessor board delivers serious graphics on a stand-alone basis. Built around the Texas Instruments Graphics System Processor(GSP),™ the graphics coprocessor board achieves a combination of sophisticated graphics and fast throughput your PC just couldn't deliver before. The GSP assumes the complete graphics processing workload, freeing your PC processor for other requirements.



New companion monitor brings together fine detail and maximum flexibility. You'll view your applications on Tek's new multiple-rate monitor. In true Tek tradition, it provides ideally balanced, 640x480 addressability and a 60 Hz non-interlaced refresh rate. So you can use advanced packages like AutoCAD,® Zenographic's Mirage™ and VersaCAD.®

Then, to move from GSP graphics to emulation of the IBM® Enhanced Graphics Adapter(EGA) mode, you simply soft-switch. And you're ready to run the popular PC packages you probably already use in CGA/EGA mode—standards like Lotus® 1-2-3,® Microsoft® WORD® and Microsoft® Windows,® to name just a few.

Last, but not least, Tek's PC4100 links you to a world of mainframe graphics. All you do is load Tek PC-05/PC-07.

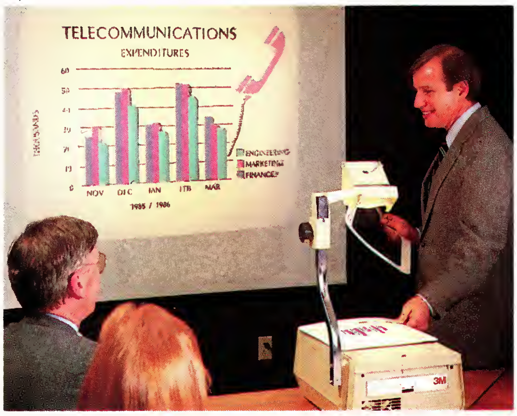
Tek PC-05/PC-07 terminal emulation software gives you mainframe accessibility with the local processing power of your PC. Because Tek PC-05 and PC-07 terminal emulation software runs under MS-DOS® 2.0 and higher, you can run your mainframe-based

AND SETS YOU APART.

applications software on your PC as if it were a Tek 4105 or 4107 terminal.

Which means you can quickly access the power of Tek graphics—including 4107 segments, true zoom and pan, rubber-banding, definition of up to 64 viewports and more. You can use these highly productive features with a wide range of well-known designer software packages such as ISSCO's DISSPLA® and TELL-A-GRAF,® MCS's ANVIL-5000,™ SAS Institute Inc.'s SAS/GRAPH, Precision Visuals' DI-3000,® Swanson Analysis Systems' ANSYS® and McNeal-Schwendler's NASTRAN.

In addition, you can utilize software development tool sets like Tektronix PLOT 10® GKS, IGL, TCS and STI software as well as numerous driver support packages created for the 4105 and 4107.



Completing the picture: perfect color output with Tek's reliable ink-jet printers. At the push of a button, the Tek 4696 lets you produce exacting color reproductions of your on-screen display on either paper or transparencies.

Because of its 120 dots per inch addressability in both horizontal and vertical directions, you can achieve resolution of up to 1280 points x 960 points per "A" size image.

All the key tools for software development, right from the outset. The new Tektronix Graphics Interface™ (TGI) for the PC provides the basics of Tek graphics functionality to application programs running under MS-DOS. What's more, in-circuit emulator, C-compiler, assembler and linker are all available from Texas Instruments to help software developers write applications packages for the PC4100 graphics coprocessor board.

To enable sufficient workspace for custom interfaces or specific application programs, the PC4100 graphics coprocessor board comes standard with a full megabyte of program memory.

Put yourself on the sure path of Tek graphics evolution. Whether you choose Tek PC stand-alone graphics, Tek's high-resolution monitor, Tek terminal emulation or all three, you can be assured Tek will keep you current with the best and most productive graphics. Because like all our products, Tek Advanced PC Graphics features a smooth built-in pathway to higher-level graphics.

For more information about how Tek lets you stand alone and work together, contact your local Tek representative about Tek Advanced PC Graphics. Or call, 1-800-225-5434. In Oregon, 1-235-7202.

TEK GRAPHICS PROCESSING SYSTEMS

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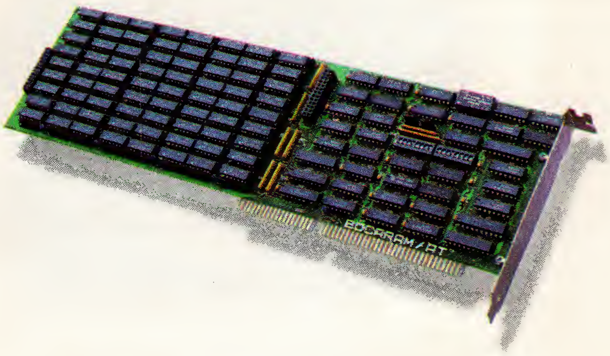


Boca Research's BOCARAM/AT expanded memory board

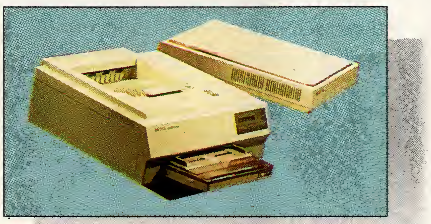
Periscope III hardware-assisted debugger from The Periscope Company, Inc.

PC/XT or PC/AT. The monitor features a nearly flat cylindrical surface with silica glass coating to reduce glare. It uses color raster display technology and a 60-Hz, noninterlaced refresh rate. The monitor's viewing area is 240 by 180 millimeters; its resolution is 640 by 480 pixels. PC4100, $2,000; monitor, $1,000; PLOT PC-05, $500; PLOT PC-07, $1,000.
Tektronix, Inc., Information Display Group, P.O. Box 1000, Wilsonville, OR 97070; 503/644-0161
CIRCLE 310 ON READER SERVICE CARD

Joining the current line of PC/AT-compatible products from **STB Systems, Inc.** is the **Grande Byte Plus** multifunction board. The 16-bit board offers memory expansion (using either 64KB or 256KB RAM chips) up to 2.5MB on one board. For I/O needs, the board provides a standard parallel printer port and an AT-style, 9-pin connector serial port. Optional features include a second serial port and a game port. Prices range from $319 without memory to $1,495 for 2.5MB of memory.
STB Systems, Inc., P.O. Box 850957, Richardson, TX 75085-0957; 214/234-8750
CIRCLE 318 ON READER SERVICE CARD

An enhanced LaserJet.from **Hewlett-Packard** (HP) has been introduced. The **HP LaserJet Series II** (HP 33440) is an 8-page-per-minute, desktop laser printer with 512KB of resident memory. Several memory boards are available for the Series II, including a 1MB board for full-page, 300-dpi (dots per inch) graphics and additional downloadable fonts and forms, a 2MB board for full-page graphics in multiuser environments, and a 4MB board for special memory-intensive needs. Approximately 30 percent lighter than previous models, this printer features an improved paper path for correct-order output. Based on Canon's LBX-SX printer engine, it has features such as two font-cartridge slots and support for a wider variety of paper stocks. The Series II has a 200-sheet input bin and 100-page output bin.

Also from Hewlett-Packard comes the **HP ScanJet**, the company's first desktop scanner. This flatbed model enables PC users to electronically scan printed images and text from a broad range of documents. The monochrome scanner features an optional automatic document feeder so that multiple-page documents can be scanned at one time. With software support, users select a resolution from 38 dpi to 300 dpi. The HP ScanJet scanner can input a full-page image at 300 dpi and store the data on a hard disk in 20 seconds. The scanner can distinguish among 16 different levels of gray for high-quality images. It supports three image-data types: binary, dithered, and 4-bit gray scale. HP Series II, $2,495; HP ScanJet, $1,495; Centronics interface card with Scanning Gallery software for HP ScanJet, $495.
Hewlett-Packard, 3000 Hanover Street, Palo Alto, CA 94304; 800/367-4772; in California, 415/857-1501
CIRCLE 317 ON READER SERVICE CARD

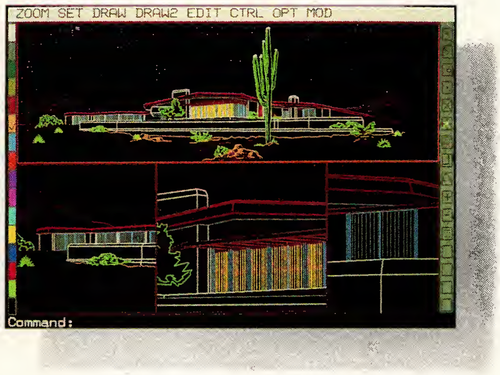


HP LaserJet Series II (front) coupled with the HP ScanJet

An expanded memory board that operates at CPU speeds as high as 16 MHz has been added to **Boca Research, Inc.**'s existing family of memory boards for the PC/AT and XT-286. The **BOCARAM/AT** offers up to 4MB of memory per board using either 64KB or 256KB 150-nanosecond RAM chips. The board can be configured with 128KB of conventional memory, bringing the system memory up to the 640KB limit, or it can be configured with up to 2MB of expanded memory that supports the Lotus/Intel/Microsoft expanded memory specifiaction (LIM EMS) version 3.2. BOCARAM/AT's extended memory, which uses the features of the 80286, can be configured with up to 4MB per board (2MB on the motherboard and 2MB on a daughterboard). Included is a RAM-disk utility for faster disk access, and a print buffer that allows simultaneous printing while accessing other PC functions. 128KB, $245; 1MB, $395; 2MB, $595; 4MB, $995; 1MB RAM chip kit, $199.
Boca Research, Inc., 6401 Congress Avenue, Boca Raton, FL 33431; 305/997-6227
CIRCLE 315 ON READER SERVICE CARD

An enhanced hardware-assisted debugger, the **Periscope III**, has been developed by **The Periscope Company, Inc.** The board monitors the system bus, watching for user-specified breakpoints to occur while the test program is running at full speed. These breakpoints can be set on memory reads and writes, I/O port reads and writes, direct memory access (DMA) activity, and may be qualified by data values and a pass counter. When the board detects that a breakpoint has been reached, it generates an NMI (nonmaskable interrupt), which activates the resident Periscope software. The Periscope III board contains 64KB of write-protected RAM that is used for Periscope's code and data. Memory breakpoints can be set on a maximum of 16 ranges from 0000:0000 to F000:FFFFH. For the PC/AT, the breakpoints also can be set on memory ranges beyond the first megabyte. Port breakpoints can be set on 16 ranges from 0 to FFFFH, and data breakpoints to 16 ranges from 0 to FFH. $995.
The Periscope Company, Inc., 14 Bonnie Lane, Atlanta, GA 30328; 404/256-3860
CIRCLE 322 ON READER SERVICE CARD

Host (left) and remote system linked by DRI's Concurrent DOS 386



Plot elevation screen produced by Evolution Computing's FastCAD

SOFTWARE

A DOS-compatible, multitasking, multiuser operating system specifically designed by **Digital Research, Inc.** (DRI) to take advantage of the Intel 80386 is available. **Concurrent DOS 386** supports the Lotus/Intel/Microsoft expanded memory specification (LIM EMS) without having to install a special expanded memory board. This operating system for the 80386 runs DOS, Concurrent DOS, CP/M, CPM/86, and MP/M-86 applications. It can run multiple DOS applications, with each one running in a separate window, and windows can be viewed as full or partial screens. Screen size, color, and shape can be defined and a keystroke switches keyboard control between windows. On a multiuser system, Concurrent DOS 386 supports remote terminals that are connected to a host system. Price is not available.
Digital Research, Inc., Box DRI, Monterey, CA 93942; 408/649-3896
CIRCLE 326 ON READER SERVICE CARD

A structured query language (SQL) mainframe connection, **PC/SQL-link**, has been announced by **Ansa Software** for Paradox, its database management system. Developed by **Micro Decisionware**, PC/SQL-link is the first in a series of SQL-related connectivity tools available to Paradox users. PC/SQL-link's menu-driven SQL generator allows Paradox users to gain access to and transfer data stored on IBM's DB2 and SQL/DS relational database systems without leaving the PC environment. Mainframe-transferred data can be easily reformatted, analyzed, and manipulated using Paradox's programming application language and application generator. PC/SQL-link also allows users to upload data previously stored in Paradox into new or existing host relational tables on mainframes. Licenses are currently available from Micro Decisionware. PC/SQL-link host license, $14,900 to $19,800; PC license, $295 to $495.
Ansa Software, 1301 Shoreway Road, Belmont, CA 94002; 415/595-4469
CIRCLE 333 ON READER SERVICE CARD
Micro Decisionware, 2995 Wilderness Place, Boulder, CO 80301; 303/443-2706
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Another mainframe connection product for Paradox is the **Paradox Connection Disk** from **Ansa**. This program works with The Application Connection (T-A-C), a product line from **Lotus Development Corporation** that includes both mainframe and PC software to access data stored in mainframe systems and to use the data in PC applications. The Paradox Connection Disk for T-A-C provides direct access to T-A-C transfer files, and enables users to import, format, and use mainframe data in Paradox applications. The Paradox Connection Disk for T-A-C is available (at no charge) only to members of Ansa Software's Major Accounts Program.
Ansa Software, 1301 Shoreway Road, Belmont, CA 94002; 415/595-4469
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Lotus Development Corporation, Information and Warranty Department, 161 First Street, Cambridge, MA 02142; 617/577-1100
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Written in assembly language for speed, **FastCAD** from **Evolution Computing**. features: four simultaneously active drawing windows; icons (available when drawing and editing) to zoom, pan, manage windows, and select colors, layers, or line styles; and powerful selection rules combined with logical operators for precise editing control. Commands and coordinates can be selected with a mouse or digitizer, typed from the keyboard, or programmed into user-defined menus and function keys. It offers floating-point accuracy with near infinite zoom, a macro language, and bidirectional exchange with AutoCAD, VersaCAD, and EasyCAD. $2,295.
Evolution Computing, 437 S. 48th Street, Suite 106, Tempe, AZ 85281; 602/967-8633
CIRCLE 340 ON READER SERVICE CARD

A complete RM/FORTRAN development environment that integrates editing, compiling, linking, and debugging into a single menu-driven system is being offered by **Ryan-McFarland Corporation**. **RM/FORTE** uses a full-screen editor for viewing and editing source code with compiler diagnostic messages visible. RM/FORTE enables movement between program output, interactive debugger, and editor, with keystroke commands. Features include a project manager, syntax checker, and automatic linking of applications using either Phoenix Software's Plink86 or Microsoft LINK. Price is not available.
Ryan-McFarland Corporation, 609 Deep Valley Drive, Rolling Hills Estates, CA 90274; 213/541-4828
CIRCLE 331 ON READER SERVICE CARD

Softguard Systems, Inc. has begun shipping the **80386 DOS Developer's Tool Kit**. With the Tool Kit, developers can write programs larger than 640KB that run in the protected mode of the 80386 under control of DOS 2.x or later. Applications developed with the Tool Kit run under an existing DOS. The Tool Kit uses Softguard's VM/RUN program to load the 80386 application into protected mode. When the 80386 application requests a DOS or BIOS service, VM/RUN automatically passes that request to DOS in the Virtual 86 mode and returns control to the 80386 after the request has been serviced. VM/RUN supports popular BIOS calls, such as keyboard and video, and also supports writing directly to video RAM. VM/RUN uses a flat-memory model—no segment registers are explicitly used. The seg-

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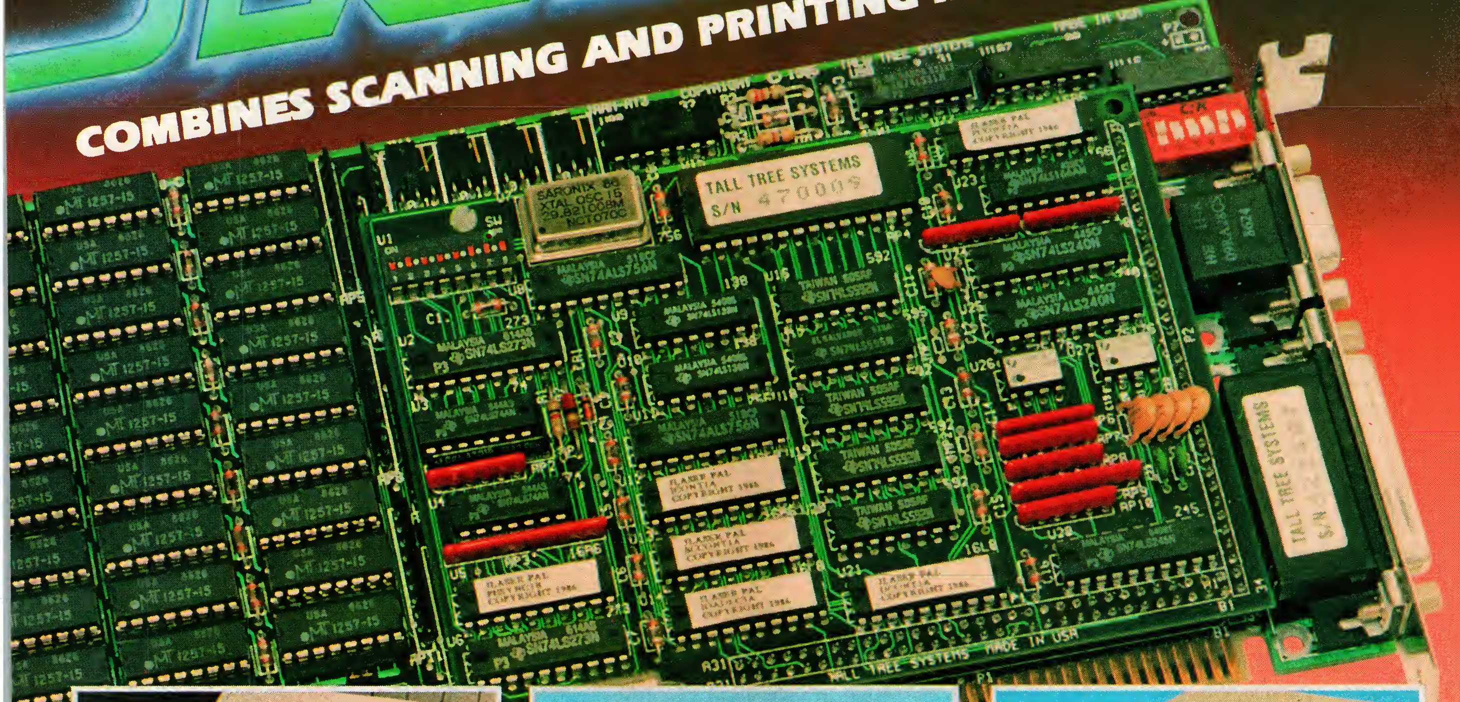

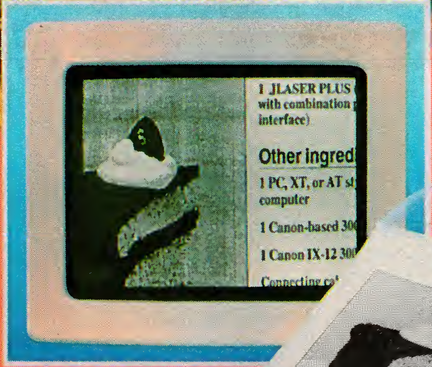

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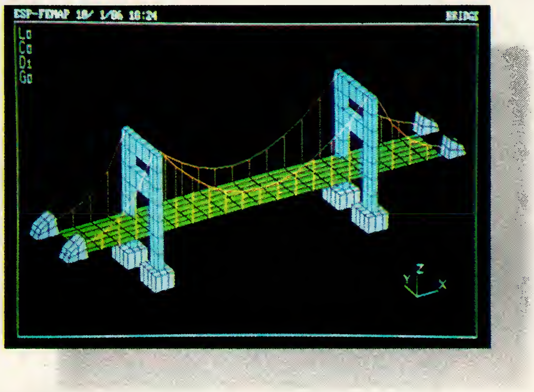
TALL TREE SYSTEMS


Screen shot of design made with FEMAP from Enterprise Software Products

Lattice dBC III Plus C Function Library

ment origins for code data and stack are all equal. Also used is Softguard's VM/DEBUG, an assembly language debugger that supports the hardware debug registers of the 80386; it can be used to set breakpoints to a specific memory locations. In addition to VM/RUN and VM/DEBUG, the Tool Kit includes a compiler (MetaWare, Inc.'s High C or Professional Pascal) and Phar Lap Software's 80386 assembler (386/ASM) and linker (386/LINK). All applications that are written with the Developer's Tool Kit will run under Softguard's VM/386 control program. Developers are allowed to bundle one copy of VM/RUN with each 80386 application they ship. $1,995.
Softguard Systems, Inc., 2840 San Tomas Expressway, Suite 201, Santa Clara, CA 95051; 408/970-9240
CIRCLE 327 ON READER SERVICE CARD

The **dBC III Plus** library of C functions from **Lattice, Inc.** enables C programmers to simultaneously create, access, and update files that are dBASE III PLUS compatible. The multiuser package lets C programmers replace dBASE III PLUS operations with C language programs, making available the many C libraries that support screen and window management, graphics, statistical analysis, and more, to integrate into their dBASE III PLUS applications. A copy of dBASE III PLUS is not necessary because Lattice dBC III Plus is a complete indexed-sequential-access method (ISAM) package. It is network-ready to share ISAM files with stations in a LAN. $750.
Lattice, Inc., P.O. Box 3072, Glen Ellyn, IL 60138; 312/858-7950
CIRCLE 332 ON READER SERVICE CARD

The first volume of the **Microsoft Windows device-driver library** has been released by **Microsoft Corporation**. The library includes support for printing devices, such as the AMT Color Ink-Jet, Hewlett-Packard ColorPro, IBM 3812 Pageprinter, and IBM Color Jetprinter; pointing devices, such as FTG Data Systems Lightpen and Maynard Electronics Mouse; and graphics devices, such as Conographics ConoVision 1440, Moniterm Viking I, Wyse WY-700 High Resolution adapter, and Video 7 Vega Deluxe with NEC Enhanced Color Display.

The **Microsoft Mouse Programmer's Reference Guide** also has been released. The guide explains how to create mouse menu programs for applications, as well as to design mouse interfaces for applications. The programmer's guide contains the tools and technical information needed by application developers to make direct calls to the driver. The reference guide comes with the Microsoft Mouse Tools diskette which contains the mouse library version 6.0, the EGA register interface library, mouse menu generation tools, and numerous samples. Library, $15; programmer's guide, $25.
Microsoft Corporation, 16011 N.E. 36th Way, P.O. Box 97017, Redmond, WA 98073-9717; 800/426-9400; in Washington and Alaska, 206/882-8088
CIRCLE 330 ON READER SERVICE CARD

A finite-element modeler has been released by **Enterprise Software Products, Inc.** (ESP). **FEMAP version 1.0** provides analysts with an environment to develop and verify both two- and three-dimensional finite element models. FEMAP includes read and write interfaces to MacNeal-Schwendler Corporation's MSC/pal and MSC/NASTRAN. The modeling package allows three-dimensional, color-shaded, hidden-line, and wire-frame plotting and supports both the IBM CGA and EGA. The FEMAP element library contains 14 element types, including beams, quadrilateral, and triangular plates (linear and parabolic); plane stress and plane strain membranes; shear panels; parabolic axisymmetric triangles; scalar springs and dampers; masses and linear tetra; and wedge and brick solid elements. Applied loads consist of nodal forces and moments, gravity, element pressures, line loads, centripetal accelerations, enforced displacements and accelerations. Constraints consist of applied boundary conditions and permanent constraints at the node level. Multilevel user-defined coordinate systems are available. An on-line calculator and a program file interface is used to customize FEMAP. $995.
Enterprise Software Products, Inc., P.O. Box 264, Harleysville, PA 19438; 215/256-1829
CIRCLE 341 ON READER SERVICE CARD

Turbo C, a C language development system produced by **Borland International**, provides a one-pass compiler, full control of memory models, and extensive code optimizations. Turbo C features a built-in lint utility with full support of ANSI prototypes. It also features in-line assembly language. A full range of compiler options are provided, including multiple levels of optimization, generation of 80186/80286/8087 instructions, warning suppression, and multiple memory models. Compiler optimizations include automatic register assignment and common subexpression elimination. It implements the forthcoming ANSI C standard and offers full support of Kernighan and Ritchie's definition. Special extensions for the PC environment include six memory models and extensions for mixed-language, mixed-model programming. Support for software interrupt functions is implemented. The Turbo C library includes standard functions and support for the IEEE Floating Point Standard. $99.95.
Borland International, 4585 Scotts Valley Drive, Scotts Valley, CA 95066; 408/438-8400
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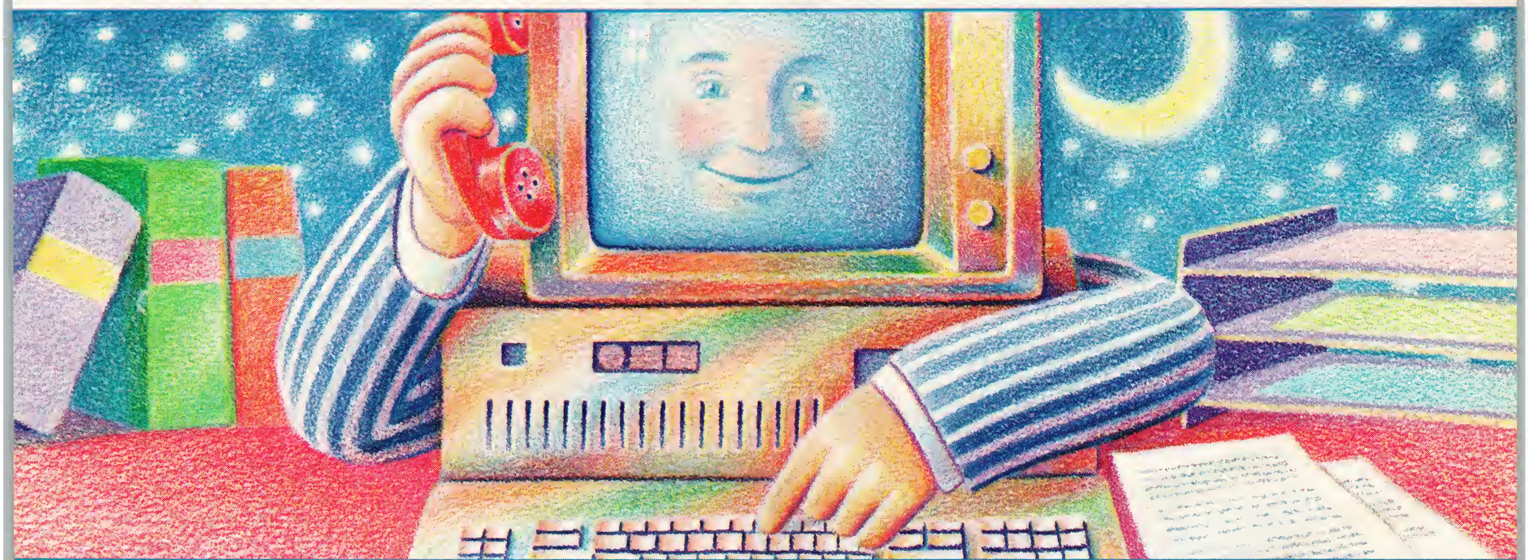
NIGHT SHIFT



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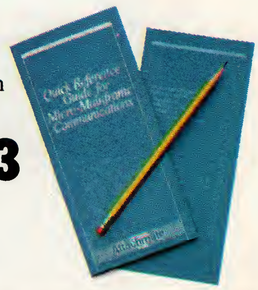

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Compatibility: The InColor Card is compatible with the thousands of programs that run on our monochrome cards.

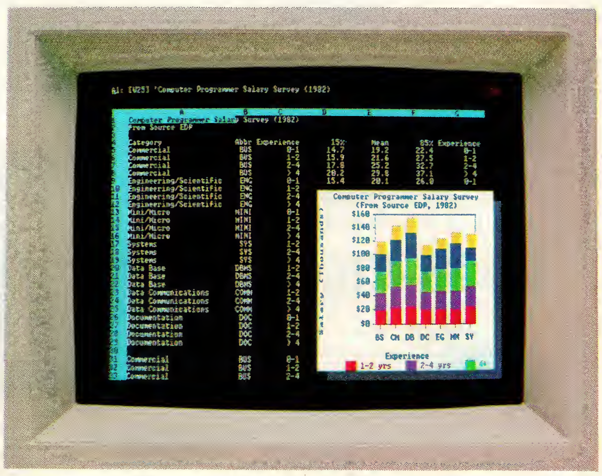
Color: The InColor Card gives color capability to Hercules-compatible software like 1-2-3® and AutoCAD®.

Resolution: The InColor Card's resolution of 720x348 is the highest of any widely supported standard.

RamFont: The InColor Card has our unique RamFont mode — in color.

Better graphics.

Hercules is known for bringing high resolution monochrome text and graphics to programs like 1-2-3® and AutoCAD®.



The InColor Card's RamFont mode gives Lotus 1-2-3 a pop-up graphics window and lets you view nearly twice as much spreadsheet data—all in full color.

Now the InColor Card gives you the same high resolution 720x348 graphics in up to 16 colors using an IBM® Enhanced Color Display, multi-sync monitor, or equivalent.

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And no other color graphics card allows you to move back and forth between color and monochrome systems *without changing drivers.*

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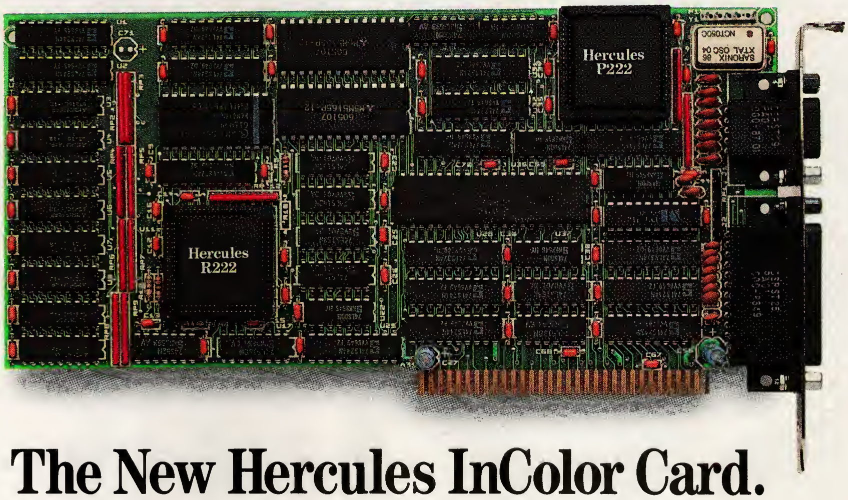
- Special RamFont mode displays 3,072 programmable characters in 16 colors with attributes, up to 12,288 characters in 4 colors
- Runs Hercules-compatible graphics software in b&w or any two background colors
- Designed for use with the IBM Enhanced Color Display, multisync monitors, or equivalents
- Software diskette includes font editor, sample fonts, and Hercules utilities
- Parallel printer port
- Two year warranty



The New Hercules InColor Card.

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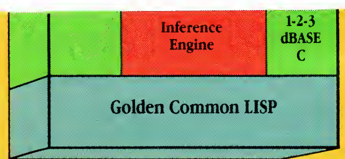

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TECH NOTEBOOK 76

JIM VALLINO

Environment Variables

Environment variable substitution, often undocumented in DOS, is an alternative to command-line arguments.

Environment variables provide an attractive alternative to command-line arguments and can be used to conveniently customize an application. An often-undocumented feature of DOS allows DOS batch files to use environment variables to control their actions, giving them more power.

The DOS environment consists of a series of ASCII variable names; each series is equated to an ASCII string by means of the SET command. Programs can look in the environment for variables that have been set by the user to control how the program should operate. This eliminates the need for the user to specify these items each time the program is run. For example, many compilers, such as Microsoft C, use environment variables to specify the location of include, library, and temporary files.

In a batch file, the notation %*n* denotes that the *n*th parameter from the invoking command line should be substituted into the file. In a similar fashion, an environment variable surrounded on both sides by a percent sign, such as %PATH%, substitutes the associated environment variable.

Environment variables first appeared in DOS 2.0, and the substitution feature for batch files has been present in all subsequent versions. A bug in PC-DOS 3.0, however, caused environment variable substitution to work incorrectly; when a variable was substituted, the remainder of the line was lost. Version 3.1 fixed this problem. No version of PC-DOS documents the substitution feature, although some versions of MS-DOS, such as Compaq's, document it clearly.

One operation that is particularly tedious to accomplish without using environment variable substitution is adding a directory to the PATH variable: the entire path must be retyped. This operation can be performed easily by using the following batch file, called ADDPATH.BAT:

```
echo off
if %1. = = . goto noarg
set path=%1;%PATH%
echo PATH now set to:
goto show
:noarg
echo Current PATH is:
:show
path
```

When ADDPATH is run, the first argument will be taken as a directory name to add to the front of the current directory list. The IF statement in the batch file checks that an argument has been given; if not, the current path is displayed.

In the batch file, the environment variable can be specified in either upper- or lowercase letters. If the name between percent signs is not the name of a variable in the current environment, an empty string is substituted on the batch command line. The environment variable substitution is performed early in the batch file, so even environment variables can be used to specify the command name.

MS-DOS does not do a thorough job of using the environment. Every time a program is run, the executable file is found by searching in the directories specified by the PATH environment variable. The COMSPEC variable defines the location of COMMAND.COM, and PROMPT specifies the string to be printed when prompting for command input. A useful feature, not provided by DOS, is the ability to use environment variables on the interactive command line. A HOME environment variable could be specified and moved to this directory by a command, such as **cd %HOME%**. The percent signs surround an environment variable that could be expanded before the command is executed.

Once environment variables have been set, a program can search the environment to find the values of those variables. At location 002CH of the program segment prefix (PSP) is the segment address of the program's environment strings. When a program is started by DOS's EXEC function call, it is given a copy of the environment from the program that started it (usually COMMAND.COM). Thus, any modifications (intentional or otherwise) made to the environment will not be retained after a program exits.

The environment is organized as a sequence of null-terminated strings of the form **variable=value**. The first string starts at the segment address designated by location 002CH in the PSP. Subsequent strings begin immediately after the terminating null character of the preceding definition. Two consecutive null characters denotes the end of the environment.

Although a program could explicitly decode the values (if needed) from the environment area, many high-level languages contain library routines to obtain variable values from the environment. Both Lattice C and Microsoft C contain a routine called **getenv** that takes as its argument the name of an environment variable and returns a pointer to the string value of the variable. For example, to allow the user to define the location of a temporary work file, an environment variable, called TMP, could be used:

```
char *tempdir, tempname[60];
if ((tempdir = getenv("TMP")) = = NULL)
   tempdir = ".";
sprintf(tempname, "%s/TEMP.DAT", tempdir);
```

If the user has set an environment variable TMP, it will be used to determine the location of the temporary file. Otherwise, the current directory will be used.

Jim Vallino is a PC programmer with experience in microcoding, high-level applications, C, and assembly language.

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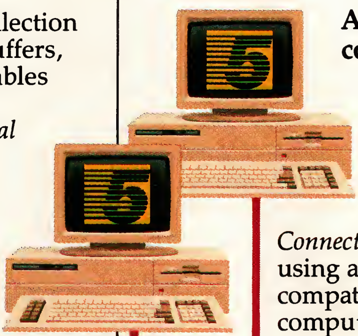

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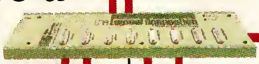
The brand new *LCSETUP* configuration program makes setting up *The Logical Connection** a snap, using any IBM-PC* or compatible computer.



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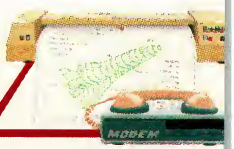

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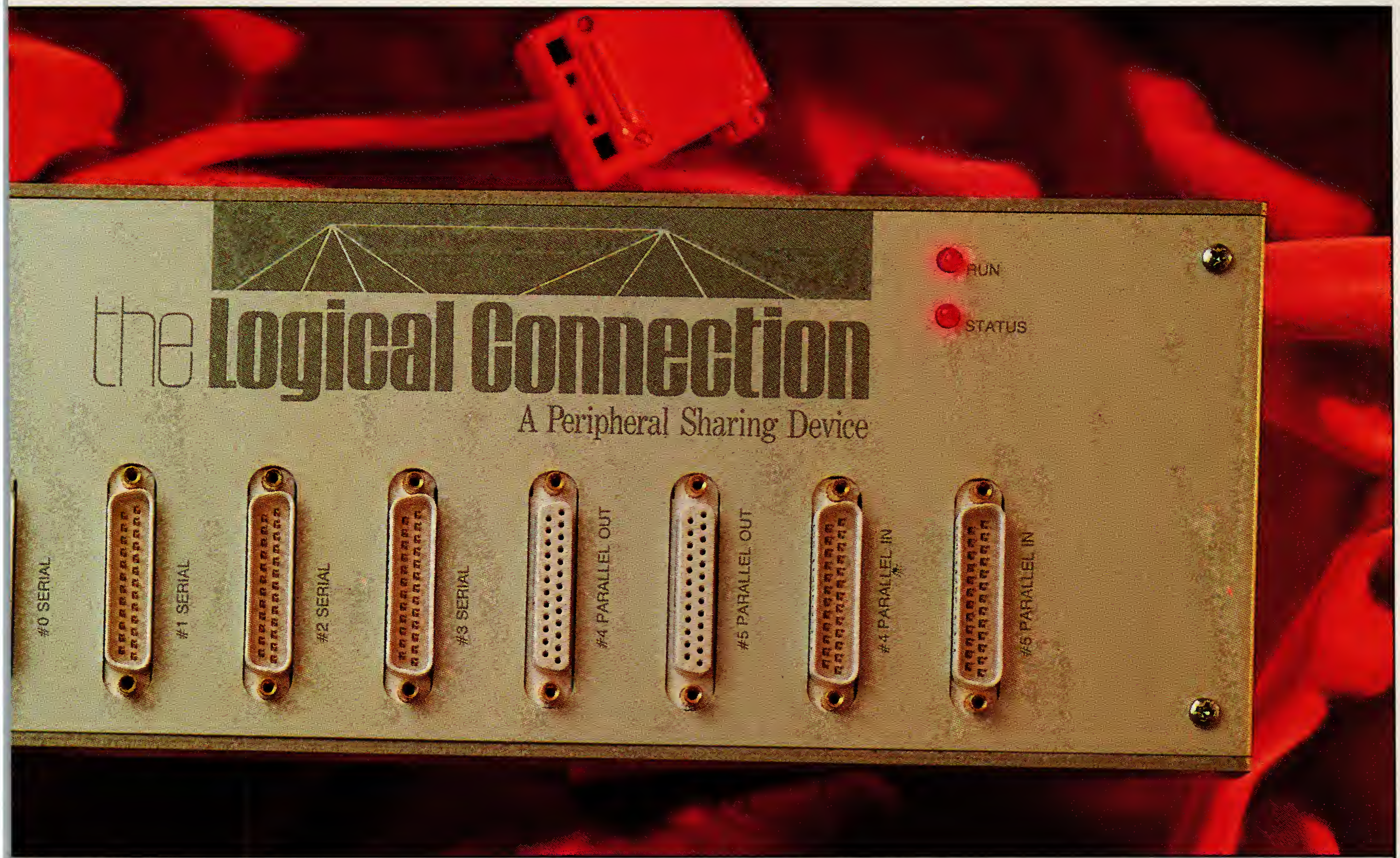

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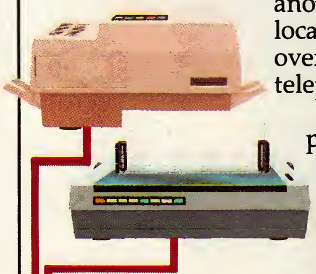

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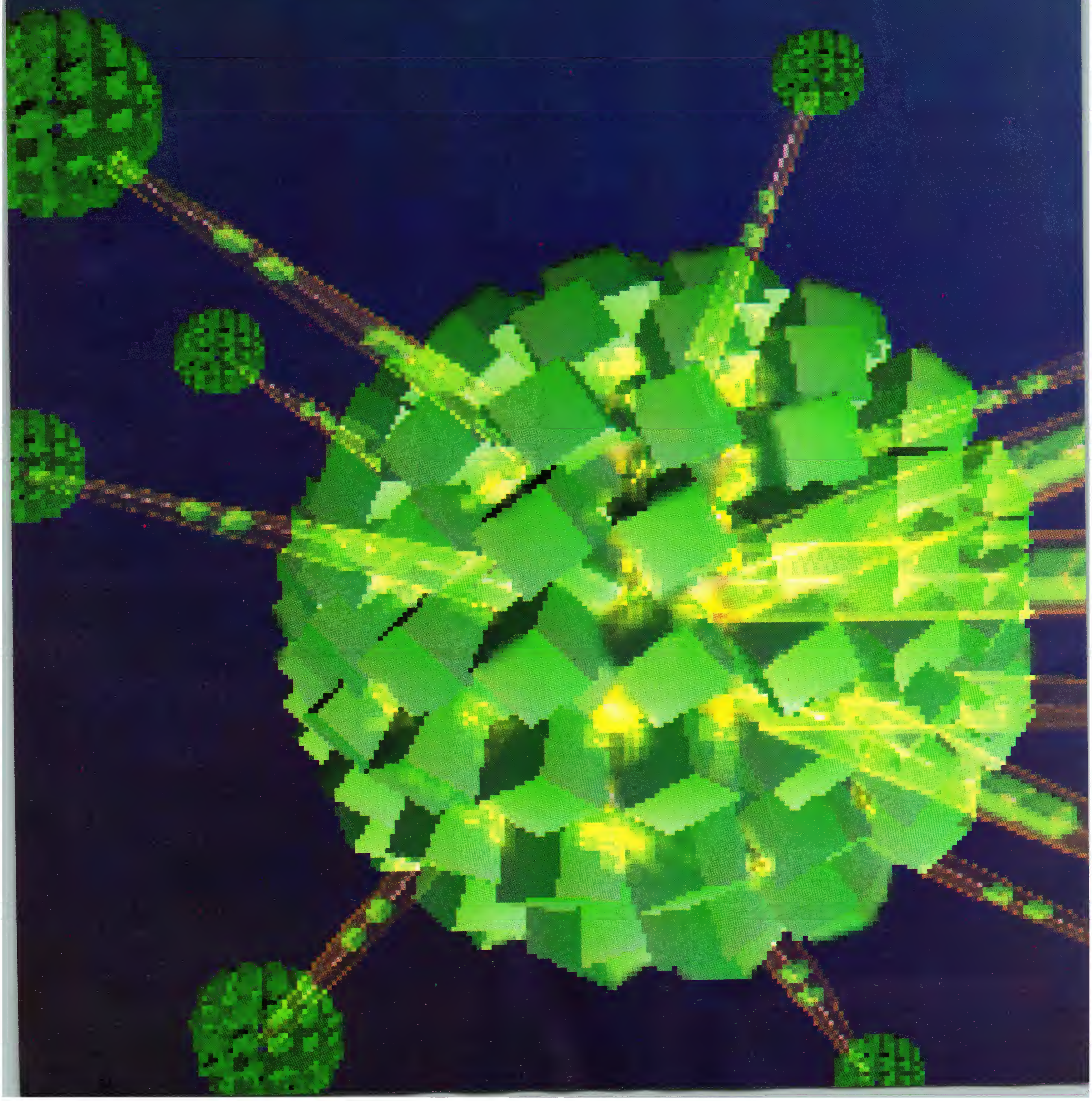
CIRCLE NO. 218 ON READER SERVICE CARD

Data Managers and LANS



DAVE BROWNING

Developments in the area of connectivity technology will play an important role in the progress of data managers for LANs.

The sharing of data by multiple users is not new: it has been done for years on mainframes and minicomputers. However, when this idea is applied to the PC environment in the form of data managers for local area networks (LANs), some fundamental differences in the implementation create the potential for substantial impacts on system operation and performance.

The primary concern of data management in a shared-data environment is preserving data integrity. In single-user data management applications, the individual user "owns" all the data and is responsible for its accuracy or integrity. In multiuser systems the ownership of each data element must be established. Many data managers provide security features to accomplish this. Ideally, each element is assigned to one individual who is responsible for its maintenance. Other users may be allowed to view the data, but only the owner is allowed to update its value.

In some cases, the ownership of data elements must be shared. For example, in an order entry system, the

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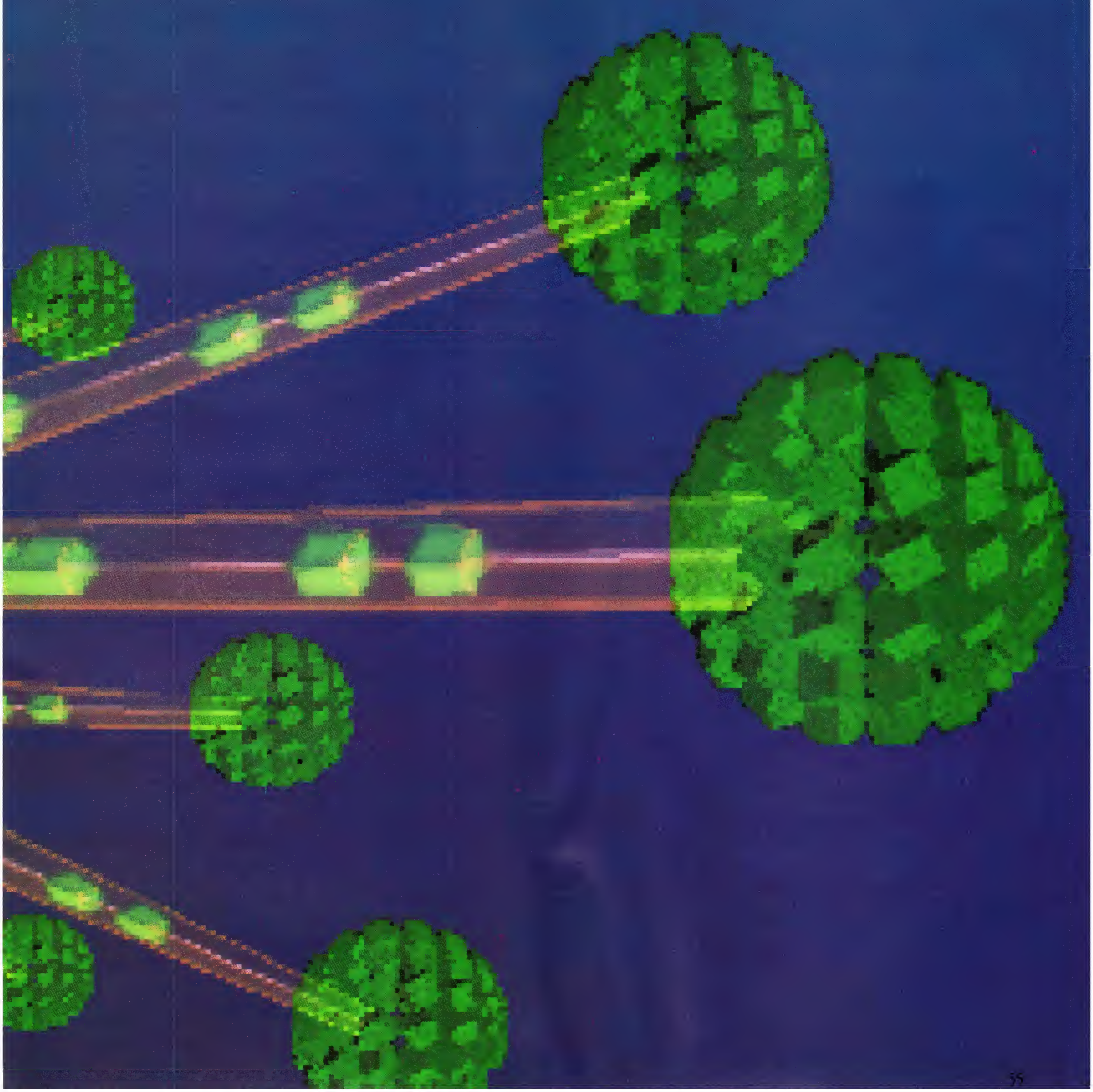


number of units of an item on hand is updated by many persons. Salespeople reduce the number of units on hand by making sales from stock, while purchasing and receiving personnel increase the number of units on hand by replenishing stock. In cases such as this, the data manager must coordinate the changes to the data elements so that the current value in the database reflects all previous updates applied by all users.

In multiuser and LAN systems, access to data must be controlled so that data changes are performed logically and systematically. The operating system provides the mechanism for locking and releasing files or portions of files upon request of the data manager. (Data locking is addressed below.)

Mainframes and minicomputers generally have a single operating system with which the data manager interacts. In a LAN, each microcomputer has its own operating system in place, and the network file server often has its own separate operating system as well. Usually each microcomputer is running a copy of the data manager, unaware of the copies running on other machines that are sharing the same data.

This article examines the methods used by data managers on LANs to address the problem of data integrity, how these implementations differ from single-user and mainframe/minicomputer multiuser systems, and how the implications of LAN data management affect the design of LAN database applications. Where common data manager, computer, operating system, and network terms may have ambiguous meanings in different contexts, a definition or description will be provided to establish a common basis for the discussion.

The mainframe/minicomputer environment provides two distinct advantages for data manager applications. First, the operating system is designed for multiuser management, and support is provided for file and record locking. Second, because all processing is performed at the CPU, it is not necessary to transfer extraneous data from intermediate operations between the computer and the terminal. For example, a query may include a request for the average salary of a set of personnel records in a table. This requires processing of several records, but the result is a single number. In the mainframe/minicomputer environment, the manipulation of the data records and the computation of the resulting average is performed by the central processor. In a LAN environment, a query such as this may require large amounts of intermediate data to be transmitted over the LAN to the user's computer, where the analysis and calculation is actually performed.

The LAN environment connects multiple computers, each running under its own operating system. The network also has an operating system that manages the server computer, and provides an interface to the user DOS. In most implementations, the individual user's DOS is unaware of the existence of the other computers on the LAN or of the LAN operating system. Interrupts are trapped by the local LAN operating system software component and directed to the local DOS or to the LAN operating system for handling as appropriate. The LAN is normally viewed by DOS as an external device consisting of a set of disk drives. This perception holds even when the inherent network feature of DOS 3.1 or later is used, because the network functions are performed by add-in programs and the processor on the network adapter card.

In both multiuser and LAN environments, all access to data must be controlled so that data changes can be performed systematically.

The LAN software provides an interface between the local application program and data located at a file server elsewhere on the network. It provides mechanisms for locking files and portions of files, permitting access by multiple users to common data.

SINGULAR DATA MANAGEMENT

Data managers are programs that store, retrieve, and manipulate data. A data manager system can be separated into two parts, the database manager (DBM) and the database application interface (DAI). This is an important distinction to make, because system performance depends heavily upon the locations of the DBM and DAI components relative to each other, to the data storage device, and to the user.

Functionally, the DBM interacts with the computer's operating system to save and retrieve raw data that are retained on the system's storage devices. The DBM also interprets directions provided by the DAI and translates them into data manipulation actions, performs the actions, and provides the results to the DAI. Data manager performance depends to some extent upon the data manager model (that is, relational, entity-relationship, or network), but optimization of storage techniques and DBM program logical design provide for a wide range of efficiency across all categories.

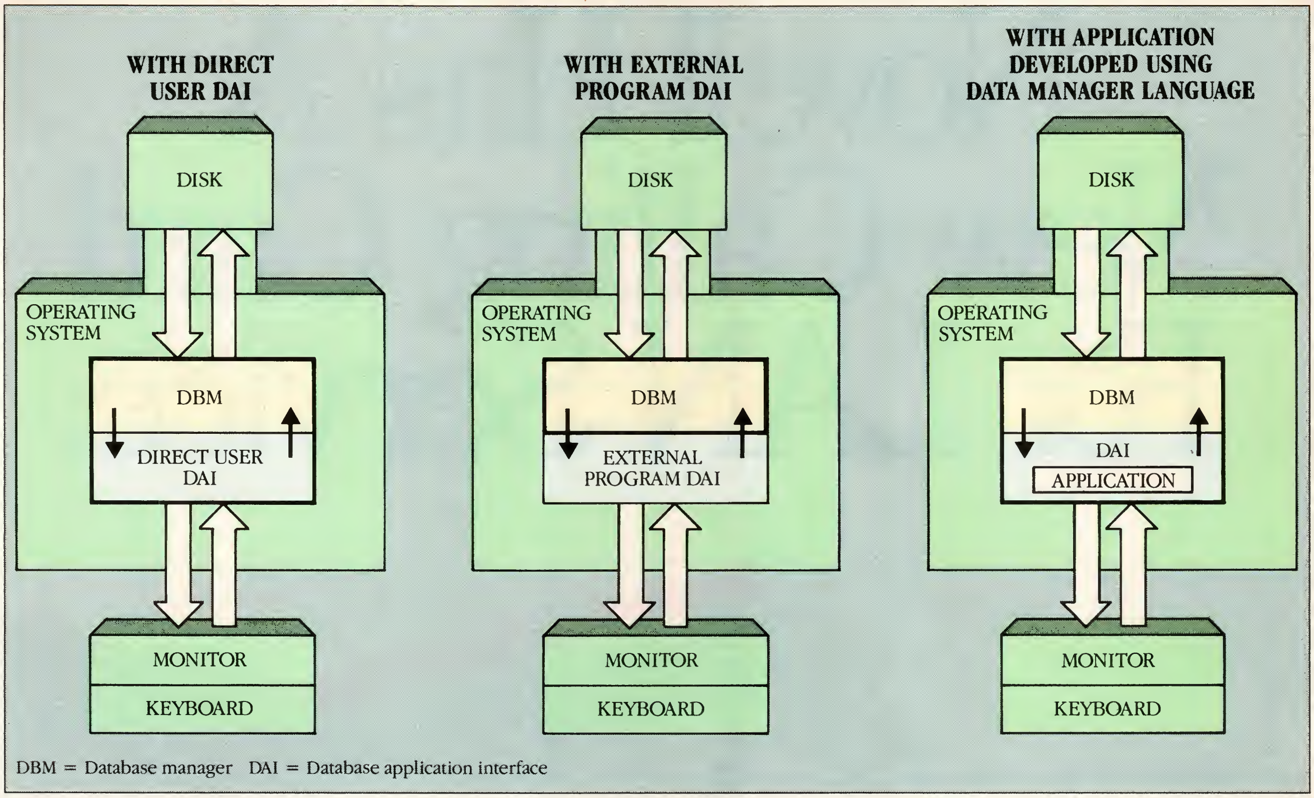
The DAI assists the user in formulating queries that are passed to the DBM. Once data are retrieved, the DAI presents the data to the user, manipulates them, and returns the updated data to the DBM. Several varieties of DAI are available. An interactive, or direct-user, DAI is provided by almost all microcomputer data managers and by many mainframe/minicomputer data managers. All mainframe/minicomputer data managers allow a custom DAI to be written in languages such as COBOL, PL/1, or FORTRAN and provide an interface from these languages to the DBM. Some microcomputer data managers support this kind of external language DAI, although most require that the DAI be written in the data manager's internal command language.

For example, dBASE III PLUS (from Ashton-Tate) contains three DAIs: the dot-prompt editor for direct, interactive entry of dBASE commands, the assistant for menu-driven user activities, and the interpreter for running customized programs written in the dBASE command language. (For a review of dBASE III PLUS, see "A Data Manager with an Evolving Standard," Dave Browning, May 1986, p. 166.) Another data manager, DataEase (by DataEase International) provides a direct menu-driven user DAI, and recently, the company has added a query command language DAI as well for generating queries. (See "A Data Manager for End-user Development," Dave Browning, September 1986, p. 146.)

Oracle (by Oracle Corporation), a relational data manager for mainframes and minicomputers, is now available for PCs running DOS and soon will be offered in a LAN version. In testimony to its mainframe origin, Oracle includes several features, such as transaction processing and back-out and extensive security, that are not found in many data managers designed for stand-alone microcomputer use. The PC version of the program contains a DBM called the kernel, a direct user DAI called the UFI (for user-friendly interface), and an external DAI interface for programs written in the C language.

Each microcomputer data manager provides at least one method for formulating queries; many offer two or more.

FIGURE 1: *Data Manager Single-user Configurations*



Data managers can be divided into two parts, the DBM and the DAI, which can work in three ways. The DAI can communicate directly with the user (left), or through an external language program DAI (center), or be integrated with an application program written in the data manager language (right). In every arrangement, the DBM portion manages data on the system disk.

Popular query DAIs are query-by-example (QBE), relational algebra, and structured query language (SQL). Applications developed either in the data manager language for the interpreted environment or in an external language can hide the data manager's query method from the user. Common queries for predetermined reports frequently are built into an application. These reports accept parameters from the user at runtime. For example, the query to perform a sales performance analysis may be quite complex, but the user would be required to provide only a date range and department selection. The logic of the query would be implemented by the applications developer.

Figure 1 illustrates some common implementations of data managers on a single-user system. The data manager is shown as a single unit divided into its two parts, the DBM and the DAI.

In the configuration on the left, the DAI is a direct user interface and communicates with the user via the keyboard and screen. The DBM portion of the data manager manages data on the system disk, using DOS calls to manipulate files. DataEase is such an implementation: the user selects activities from menus and enters data under full control of the DataEase program.

In the center configuration, an external program DAI is used to communicate with an application program that is written in a general purpose language, such as C. The application program performs the communication with the user, issues directives and presents data to the DBM, and receives data from the DBM for presentation to the user. An application program that is written in C for the Oracle data manager or for Softcraft's Btrieve file manager would be an example of this configuration.

The configuration at the right in figure 1 is one in which the data manager includes an internal programming or command language DAI. In this situation, the application program communicates with the user through the DAI; the DAI then issues the appropriate DOS calls to communicate with the user. A dBASE or Microrim R:base 5000 application program being executed by the data manager's command interpreter is an example of this implementation. (For a review of R:base 5000, see "A Data Manager with Kernel Code Generation," Steven Armbrust and Ted Forgeron, September 1985, p. 82.)

MULTIUSER CONFIGURATIONS

In multiuser mainframes and minicomputers, various configurations are available for the operating system and a data manager to serve more than one simultaneous user, as shown in figure 2. In a virtual machine configuration (on the left), the computer system is controlled by an umbrella operating system (such as the *control program* in IBM's VM system). Each user is provided with a virtual machine that appears to the user as a fully configured computer, complete with its own operating system. Within a virtual machine, the data manager operation may be the same as any of the implementations described above for single-user systems.

When two or more virtual machines contain copies of a data manager accessing the same database, each copy must use the locking mechanisms provided by the operating system to protect data integrity. The application programs are prevented by the operating system from interfering with locked data—this can be thought of as a *physical lock*. Other locking mechanisms called *logical locks* may be designed on an application-specific basis. Locks such as these draw support from the operat-

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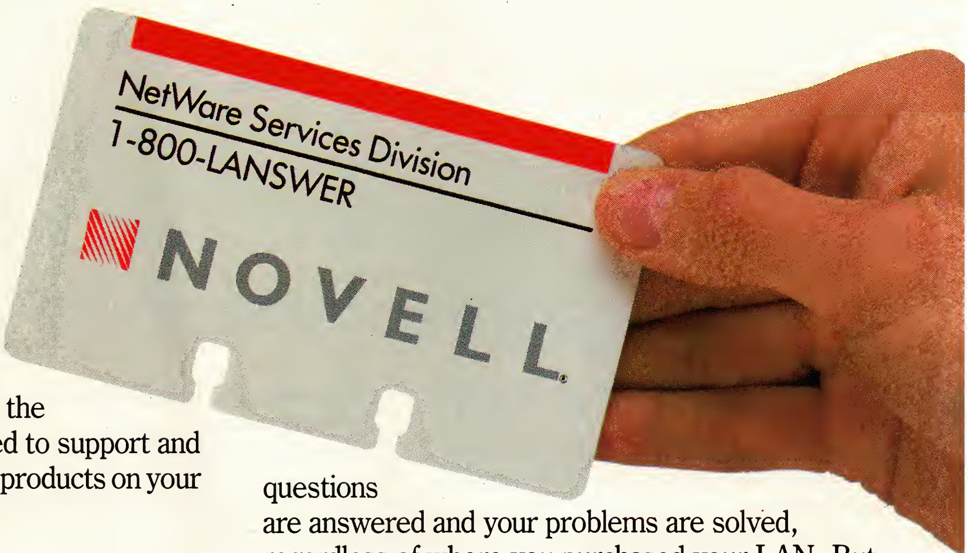

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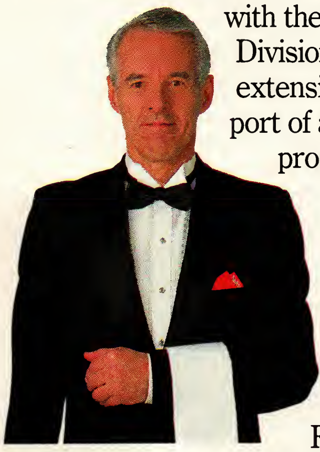

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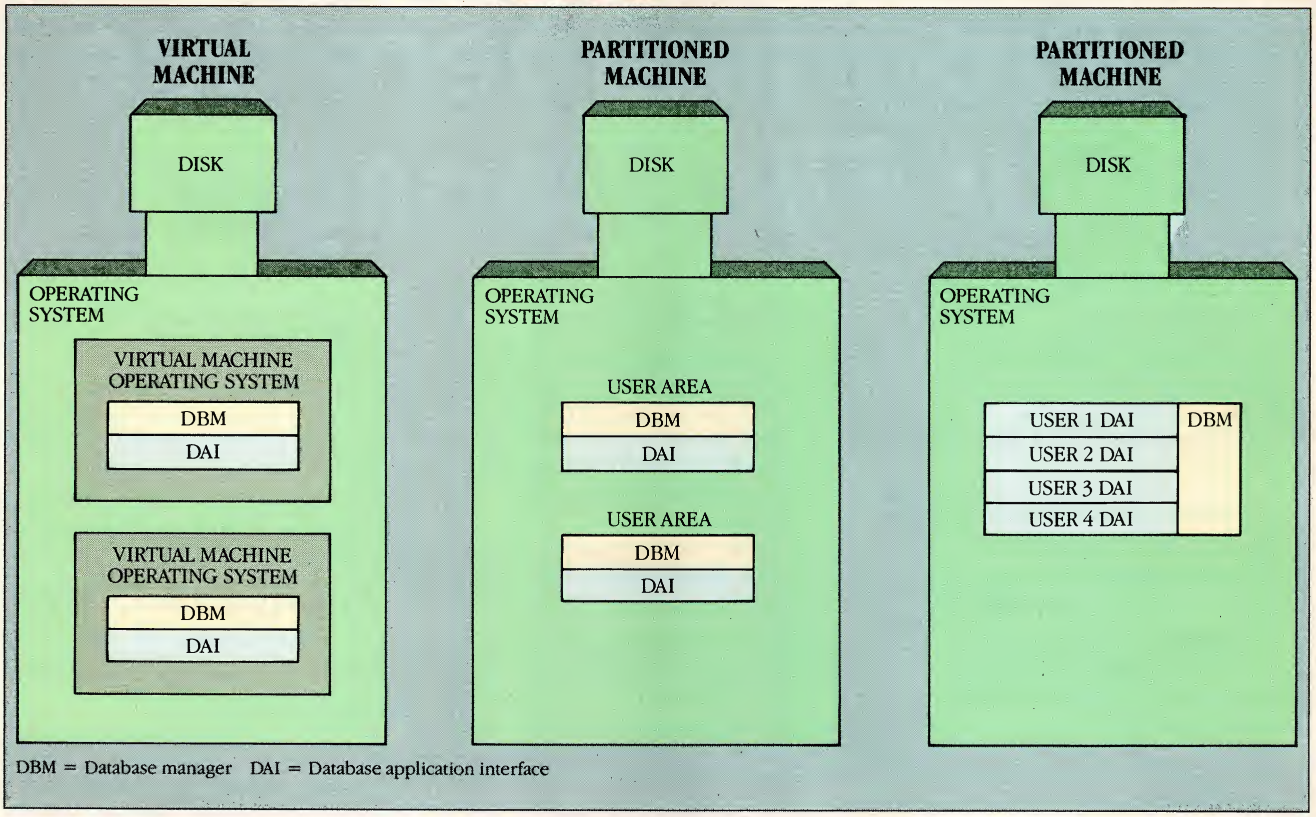
FIGURE 2: *Data Manager Multiuser Configurations*



In a virtual machine configuration (left), each user is provided with what appears to be a fully configured computer, complete with its own operating system. A machine with partitioned memory (center) is similar, but with each data manager executing in separate user areas. A centralized approach (right) is achieved with a single DBM interfacing with multiple copies of the DAI.

ing system in the form of mechanisms such as semaphores, but the application programs are responsible for respecting these types of locks.

In a similar multiuser configuration (center), memory is partitioned into user areas into which copies of data managers and other application programs may be loaded. System resources are managed and allocated by the central operating system, and application programs must be designed to run under the specific operating system used in the computer. Simultaneous access to a single database again requires administration of locking mechanisms by the operating system in place, and the data manager copies must be aware of the locks and respect them.

The configuration shown at right in figure 2 illustrates a mainframe/minicomputer set-up in which the DBM has been designed to perform data management services for any number of simultaneous users. The data management code for this system is written to be reentrant, and a single centralized copy of the DBM is loaded into the computer under the operating system. Then, separate user areas are loaded with the appropriate DAI and application programs. This centralized DBM approach, although more difficult to design and develop, maximizes the effective use of system memory, and provides a closer coupling between the data management program and the operating system.

LAN implementations share similarities with both the single-user and the partitioned multiuser configurations just described. Figure 3 shows the arrangement of a data manager operating on a single-user machine connected to a LAN. The data manager looks to the operating system to provide access to data and management of the locking mechanisms. Data that are to be shared with other users connected to the LAN normally will reside on the mass-storage device at a network file-server machine. The LAN interface at the local user machine provides two services needed by the data manager: first, the network mass storage attached to the server is mapped into unused local disk drive designation letters; second, it makes available a method for the application programs to communicate with the network operating system for functions that control data locking.

With the release of DOS version 3.1, IBM and Microsoft introduced a network interface. (See "The Ascent of DOS," Ted Mirecki, October 1986, p. 92.) Certain DOS interrupts, most often file and print I/O requests, are redirected to the network operating system for action through a program called a redirector. Many non-IBM networks support this design and are considered to be DOS 3.1-compatible. In these networks, a device driver or a memory-resident program is loaded to supplement DOS with the proper interrupt handling for the network. Application programs such as data managers need only use the appropriate DOS calls for I/O and locking functions to be compatible with a variety of networks.

The IBM PC Network is considered a *peer* network in that no dedicated host computer or server is present. The server portion of the IBM network software allows any PC on the network to perform server functions, namely access to mass storage and print devices, while also functioning as a PC. In other networks, servers often are dedicated PCs, or even specially designed server computers. To a data manager executing in

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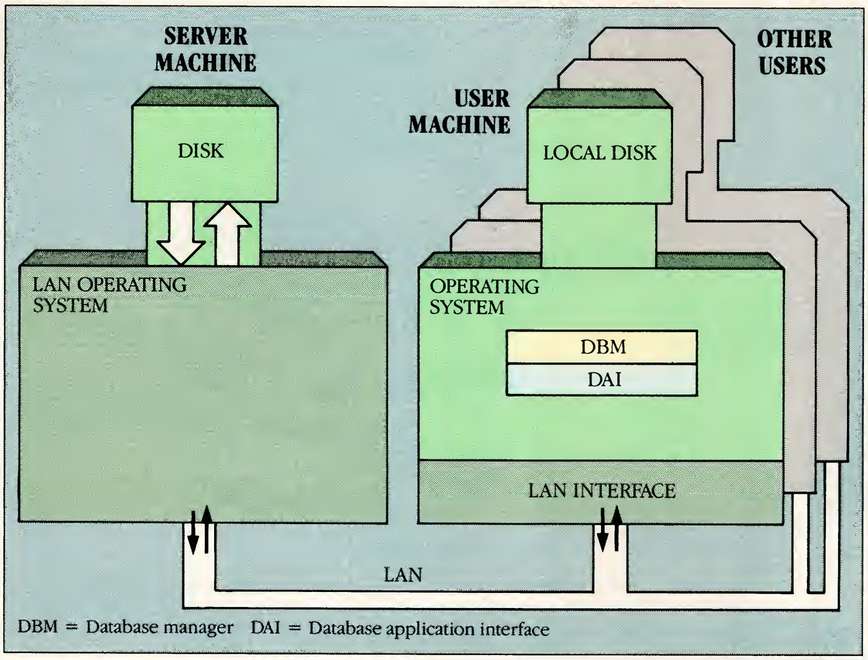
FIGURE 3: *Data Manager LAN Configuration*



Data to be shared among users on the LAN reside in mass storage at a network file server. The DBM at each machine communicates over the LAN with the server operating system, which provides access to data and manages locking mechanisms.

a local PC on the network, the fact that file storage is being provided by a remote computer over a network interface is not logically relevant; the data manager simply requires access to data, regardless of its location.

ACCESS AND LOCKING

Data managers that are operating in a shared environment must provide control of access to that data in two important ways: first, control of access to certain data elements for security reasons to prevent modification by inappropriate persons; and second, control of time-sensitive data locking in order to prevent simultaneous modification of data elements by multiple users.

LAN operating systems generally furnish a mechanism for providing security at both the user and file levels. Log-on procedures can be established by the network administrator via the creation of a user profile for each user or group of users to restrict access to specific directories and files. In addition, files may be assigned combinations of permission attributes such as read, deny read, write, deny write, modify, create, extend, delete, and share. These terms do not hold the same meanings across all networks. For example, write permission may include both replacement of existing data and addition of new data in one system, but can be separated into the more specific permissions of modify and extend in another. Also note that not all networks provide all file permission attributes.

Many data managers supplement the network permission and file-attribute modes with other security mechanisms. Depending upon the data structure used by the data manager, access may be granted to individual users on a file, record, field, or formula basis. For example, low-level workers in a personnel department may be granted access to all employee home addresses in the personnel files for update purposes, but may be restricted from viewing or changing salary information for employees whose salaries are above a certain level. These supplemental data access functions require the execution of an additional log-on process, supplied by the data manager program, prior to performing data management activities.

Audit logging of changes that users make to database data for security and recovery purposes is provided by some data managers. Audit log files may record various information, including the date, time, user ID, and name of the file or field modified. They also may hold the actual content of deleted records or field values prior to modification. Audit trails can be useful for locating the source of data errors, restoring databases to previous states, and determining the identity of users modifying particular database elements.

Once access to database functions has been established, users must be protected from interfering with other users as they manipulate data. This is perhaps the most important function provided by data managers employed in multiuser configurations.

To prevent simultaneous data update, a mechanism must be in place within the system to lock data elements while they are being modified. This mechanism must be administered by the operating system on the network file server or the central operating system of the multiuser machine so that access to data from all asynchronous processes (applications programs) operating in independent machines or independent user areas in a single machine can be controlled centrally.

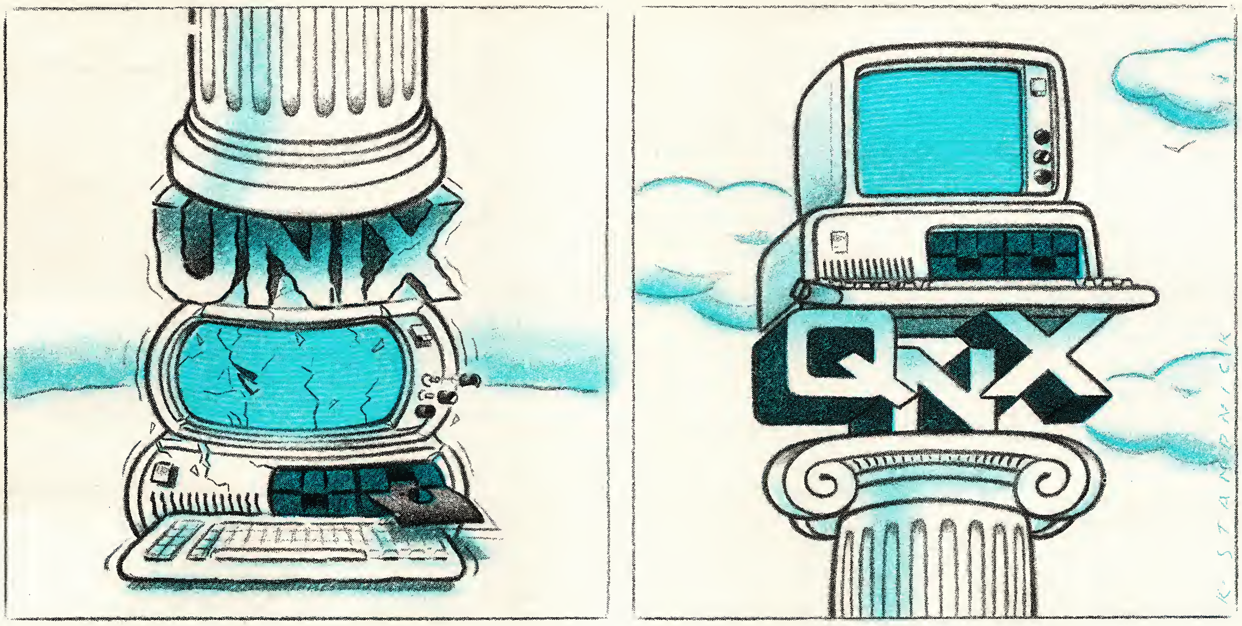
Data may be locked at the file, record, or data-element level. A file may be locked to prevent writing (deny write), reading (deny read), or any use of the file (open exclusive).

Generally, to lock a data region in a file, the data manager would call an operating system function, passing as parameters the file, a starting byte offset in the file, and an ending byte offset (or a starting offset and region length). The operating system then would respond with an indication of the success or failure of the particular request.

In some systems, a time-out period can be a part of the lock request; if the operating system is unsuccessful in locking the requested area in the time period specified (because it is already locked by another program), then the operating system returns a failure status. Under operating systems that do not support a time-out error, the program could retry locking the record a predetermined number of times.

If the lock has been successful, other user programs attempting to write to the locked area are prevented from doing so by the operating system until the area is unlocked by the program that set the lock. The locked data area may or may not correspond to logical records in data files. Most data managers that provide locking functions to applications developers do so on a logical-record level.

The ZIM data manager (by Zanthe Information, Inc.) locks data areas on a page basis automatically without the need for explicit requests by the applications programmer. (See "A Data Manager Using Entity-Relationships," Richard M. Foard, October 1985, p. 96 and "ZIM Release 2.5," Product Watch, Richard M. Foard, June 1986, p. 195.) dBASE III PLUS provides functions for rec-



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ord locking and file locking. For execution from the dot prompt or in assist mode, locking is performed automatically; programs that are written for the interpreter must manage locking and unlocking themselves.

Semaphore locking provides the ability to coordinate access to a resource through the use of a predefined signal. The operating system provides a table in which a program places a semaphore when it takes control of a resource; the semaphore is removed when the program releases control. Other programs then check the semaphore table to see if a needed resource is in use. The operating system also may manage queues of requests for semaphore locks on a first-come–first-served basis. Semaphore locks must be checked by the programs involved in the application because the operating system has no knowledge of the logical meaning of the semaphore.

These semaphore locking mechanisms may be advantageous for specific applications in order to minimize the use of low-level operating system locks. For example, in one dBASE III PLUS application, logical records were associated with specific individuals; the data items comprising the logical records were spread over several dozen files and were related by a unique key value that was derived from the individual's name. Rather than requiring each program to lock all records applying to the individual, a small log file (a dBASE data file) was established to hold the keys of logical records currently locked and the identity of the user locking the record. Because all programs in the application were designed to check this log file before attempting to call up a logical record for modification, no additional locking was required. The dBASE III PLUS lock functions were used to lock the log file records when logging a key in order to prevent simultaneous logging of a single key by two users.

When changes are made that affect an entire file (such as reindexing, removing deleted records), the file often is locked. This may have a negative impact on performance because no other user may access the file for the duration of the lock. Using record locks where possible mollifies the effect on performance by making the remainder of the file available during the time one record is being updated. Even with record locking, though, contention for the same record may degrade response time. If a record is locked from the time it is read until it is updated, the time it is unavailable may be unacceptably long—the user may, for example, need to consult with someone else before making the update. Contention for the same record can be minimized by locking the record only for the time required to commit the update to the file.

Problems can arise in using this method. First, a data element's new value is often derived from its current value. If the current value changes from the time the record is read until the user is ready to apply the update, the user must be informed, so he can take appropriate action. Second, multiple users may be updating separate fields in the same record. One user's update should not overwrite fields other than the ones he has changed.

As an example of the first situation, consider an inventory stock file that contains two fields, stock number (STKNO) and quantity on hand (QOH).

Semaphore locking mechanisms provide the ability to coordinate access to a resource through the use of a user-predefined signal.

Several users are accepting orders for items over the telephone or at store sales counters. The process of making a sale is, first, to determine the quantity desired; second, to compare the quantity desired with QOH; and third, if the quantity desired is less than or equal to QOH, then to reduce QOH by quantity desired and enter order, else abort the order. The problem arises in the second and third steps.

Suppose 10 units of an item are on hand, and two orders are being placed. One order is for 6 units, the other is for 7. Both order clerks query the QOH of the item, and see that it is 10, sufficient for the sale. The first user places the order for 6 units, decreasing the QOH from 10 to 4, and replaces the QOH in the file with the new value of 4. Meanwhile, the second user has compared the QOH value 10 to the order quantity of 7, determined that a sufficient amount is on hand, places the order for 7 units, decreasing the QOH from 10 to 3, and replaces the QOH in the file with the new value of 3. In this uncontrolled situation, a total of 13 units have been sold from a QOH of 10, and the QOH now says 3 are left. If the second order had been entered first, both orders would still be placed, and the QOH value would be 4.

Because the decision of whether to update the QOH value depends upon the value at the time it was read, it would appear desirable to lock the value from the time it is first read until it is modified, thus preventing access by other users until the order process has been completed. This technique works, but it may introduce unacceptable time delays. If human action is required between the time the QOH value is read and the time the order is confirmed, the process can be easily interrupted, keeping the record locked for a substantial period of time.

A more workable solution in this case would be to eliminate the second step above (that is, querying the status of QOH) and, instead, simply to lock the record and attempt to place the order. If the file shows that sufficient QOH exists, the order is placed and QOH is updated in one step, requiring minimal lock time without human action during the lock period. If QOH is insufficient, the order is rejected and the operator informed of the rejection. The clerk then might query the actual QOH and attempt a new order of a lesser amount. This new order also might fail if another order was accepted during the time the first clerk read QOH and attempted to place a new order, but at least the integrity of the data in the file has been preserved.

Figure 4 provides (in pseudocode) an algorithm that could be used to implement the process mentioned above. The update process has been compressed into a procedure in which human intervention was not required during the period the record was locked. Note that the record lock action was performed as a command to lock the record and a check for an error return. No test for a locked condition was made first. This is the normal procedure, as the process of testing for a locked condition and then requesting the lock as a separate command leaves a time gap in which the record could be locked by another user. The error check on the lock command still is required; thus, the test is superfluous.

In another situation, one user may be assigned to update salary information in employee records, while another user is responsible for updating addresses in the same employee file. Even though the two users do not intend, or are not allowed, to update each other's fields, the data manager may write to the file on a record-by-record

FIGURE 4: *Record-locking Code*

```
OPEN Stockfile FOR SHARED UPDATE
DO FOREVER
  PERFORM GetOrder
  READ RECORD WITH Stock.Number = Order.Stock.Number
  LOCK RECORD ON TIMEOUT PERFORM Excessive.Lock.Time
  IF Qoh - Order.Qty >= 0 THEN
     REPLACE Qoh WITH Qoh - Order.Qty
     DISPLAY MESSAGE "Order placed."
  ELSE
     DISPLAY ERROR MESSAGE "Order rejected - insufficient QOH"
  ENDIF
  UNLOCK RECORD
END
```

The pseudocode above is designed to ensure data integrity. The update process is designed so that the record is locked for the briefest possible time. The record is locked, read, and the update attempted. If the record is unavailable, the system retries for a specified amount of time before failing.

FIGURE 5: *Signature-checking Code*

```
OPEN Employees FOR SHARED UPDATE
DO FOREVER
  READ Employee.Record
  Check.Sig = Record.Sig
  PERFORM Get.New.Address
  READ Employee.Record
  LOCK RECORD ON TIMEOUT GOTO Excessive.Lock.Time
  IF Check.Sig = Record.Sig THEN
      REPLACE Employee.Record.Address WITH New.Address
      REPLACE Record.Sig WITH MOD(Record.Sig+1,1000)
      DISPLAY MESSAGE "Address Updated."
  ELSE
      DISPLAY ERROR MESSAGE "Record has been changed "
  ENDIF
  UNLOCK RECORD
END
```

The record is read and the value of the Sig field saved. When the updates are ready, the record is locked and reread. If the value of the Sig field has changed, the record has been updated between readings. If the value is the same, the updates are made and the Sig field is then incremented.

basis instead of on a field basis. This type of record management is common in data managers, and the applications programmer must give some attention to the potential for corrupted data. The situation could arise in which both users read the same record, one makes changes to the address field and rewrites the entire record, and the second makes changes to the salary field and rewrites the entire record. The second user's update restores the address to the original value, which, in turn, voids the first user's changes to that field.

DataFlex (from Data Access Corporation) avoids this problem by performing updates at the field level in the LAN environment, where only those fields changed by the program are rewritten instead of the entire record. (For a review of the DataFlex product, see "A Data Manager for Diverse Environments," Chris Christian, August 1985, p. 52.) Some data managers that rewrite entire records provide a command or function that checks a new record read against the record value last read.

For other data managers a technique called *signature checking* can be applied. In each record a numeric field called Sig is used to determine if the record was modified since it was last read. As shown in figure 5, after the record is read, the value of this Sig field is saved. When the clerk is ready to update the record, the record is reread and locked. The signature value is compared to its value when the record was originally read. If the value is different, then the record has been updated by someone else. If the value is the same, then the updates are applied with the confidence that the integrity of the data has been preserved.

Locking on a record or field level is not always possible. The open exclusive file lock is often used when changes are to be made to several or all records in a file, such as file pack (removal of records marked for deletion) and file indexing. For data managers in which indexes are implemented as separate files, changes to data in an indexed field require a change to the index file contents. If two users make simultaneous changes to the same key field in different records of the data file, the corresponding changes to the index file must be controlled to prevent corruption of the index. The data manager normally needs to lock the entire index file while the index pointers are being changed, but the time for this operation is under total control of the data manager. The index update does not occur until the user program attempts to rewrite the record. The data manager then can lock the index file, effect the change, and unlock the file in one operation. The applications programmer need not be concerned that two copies of the data manager may be updating the same index file.

Another consideration for the designer of a multiuser database system on a LAN is the management of data buffers. The objective of record locking, as explained above, is to prevent data from being updated while another user is also updating a copy of the data. Because of the number of different computers and data transmission systems involved, several layers of buffer may be present between the data storage on the file server's disk and the user's application program: the LAN server program may buffer the data stream to or from the disk; the LAN communications boards may include communications buffering; the local user's DOS provides buffers for data in local and remote files being processed using DOS commands; the data manager may provide its own data buffers; and the applications program may accumulate data in memory variables during user input. These are all forms of data buffer, and they all must be managed so that only the correct copy of a data element is updated and stored. Some of these buffers can be controlled only by the operating systems involved, others only by the data manager. The data manager program must request the operating system to flush the buffers to disk before unlocking the record. The applications programmer must be responsible for data buffered within memory variables in application programs.

DEADLOCK DETECTION

Also known as deadly embrace, *deadlock* is a circular wait condition that occurs when a user requires more than one resource (file, record, record set) to complete a task, has locked part of the resources, and is waiting for the remainder of the resources to become available. At the same time a second user has locked a portion of the same set and is waiting for the resource the first user has locked. An example of this situation is the requirement to lock both a parts record and a vendor record to perform a part number and discount change. If the first user locks the parts record at the same time a second user locks the vendor record, the first user must wait for the vendor record to become available before proceeding. Meanwhile, the second user has locked the vendor record and is waiting for the

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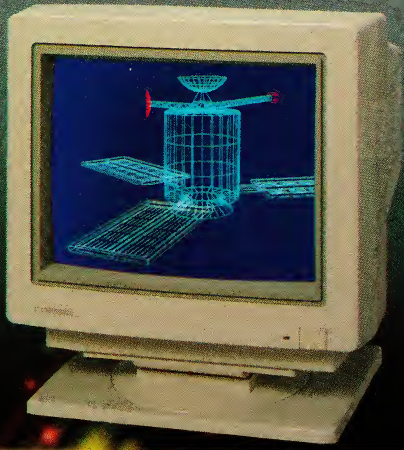

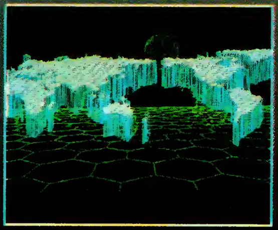

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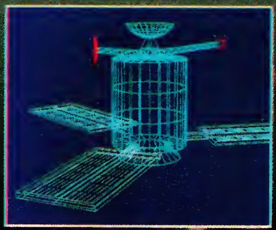
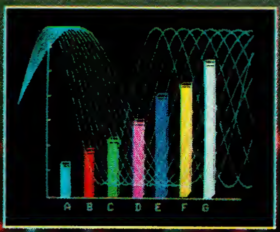


EGA



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parts record to become available for locking. This is a simple case. Many real cases are more insidious—involving more than two records or users and other files, such as parameter files or other secondary resources.

Once a deadlock condition has been detected, the usual recovery procedure is to choose a victim and abort that user's process, thus freeing up the locked resources for the nonvictim process or processes. Of course, the preferred method of dealing with deadlock is prevention, and three common techniques are available.

If the network, operating system, or data manager provides a service called *set locking*, then the program simply supplies the operating system with the list of simultaneous resources needed and requests that the set be locked. Then the set is locked only if all resources are available.

Another method to avert deadlock relies upon *cooperative processing* of all programs accessing the same database. It is agreed that each program will always lock resources in a predetermined sequence. No copy of a program can lock any item on the list unless all previous items have been locked. In this case, the first program to lock the first item on the list is home free because no other copy can get beyond the first item to lock any of the others in the set. This technique counts on each program complying with the agreed-upon sequence. However, some subtle interference between sets of resources required for totally different purposes could take place that still would allow a deadlock condition to occur.

The *lock back-off* technique can be implemented through programming structures and provides a secure solution to most deadlock problems. In an application designed to use lock back-off, a program attempts to lock a set of items one by one. Whenever an item cannot be locked, the entire set of locked items is released and the program starts over again after waiting a randomly determined amount of time. This procedure will assure that no process holds resources while waiting for others to become available.

Many data managers offer automatic record locking; some, including dBASE III PLUS, also caution the applications developer that deadlock avoidance is the responsibility of the programmer. Usually, automatic locking can be implemented by the data manager only in those situations in which user activities are controlled by a direct user DAI provided by the data manager. Also, where a set of multiple resources must be locked during a specific process, as illustrated above, the developer probably needs to incorporate the deadlock avoidance logic into the programs.

The problem of deadlock often arises in *transaction processing* in which multiple resources need to be locked simultaneously. Some data managers offer direct support for transaction processing and provide services such as transaction logging and transaction back-out to avert the situation.

For an application in which changes to multiple files must be made before others are allowed to use the new data, as in the case of adding a new customer and a simultaneous order for that customer, explicitly defined transactions may be used.

Sophisticated query optimization techniques can improve the performance of relational data managers, but they are new to micros.

The ZIM command **transaction**, for example, marks the beginning of a transaction. During a transaction, any part of the database read is read-locked (others may read, but cannot update) and any portion written is write-locked (others may not read or update). The **endtransaction** command marks the completion of the transaction; the changes are applied to the database, and the locked resources released. If the transaction cannot be completed for any reason, **quittransaction** is used: the transaction is aborted, the pending changes are discarded, and the reserved resources are released.

ZIM uses the **transaction** and **endtransaction** commands to detect deadlock conditions in which different users have applied changes to portions of the database and then attempt to lock data within another user's transaction-locked resources. When such a deadlock situation is detected, ZIM selects one of the processes to be the victim, and aborts its transaction, in the process discarding the victim's pending updates as if a **quittransaction** had been executed. User code is required to test after update or read operations for an error code to determine if the transaction has been completed or not.

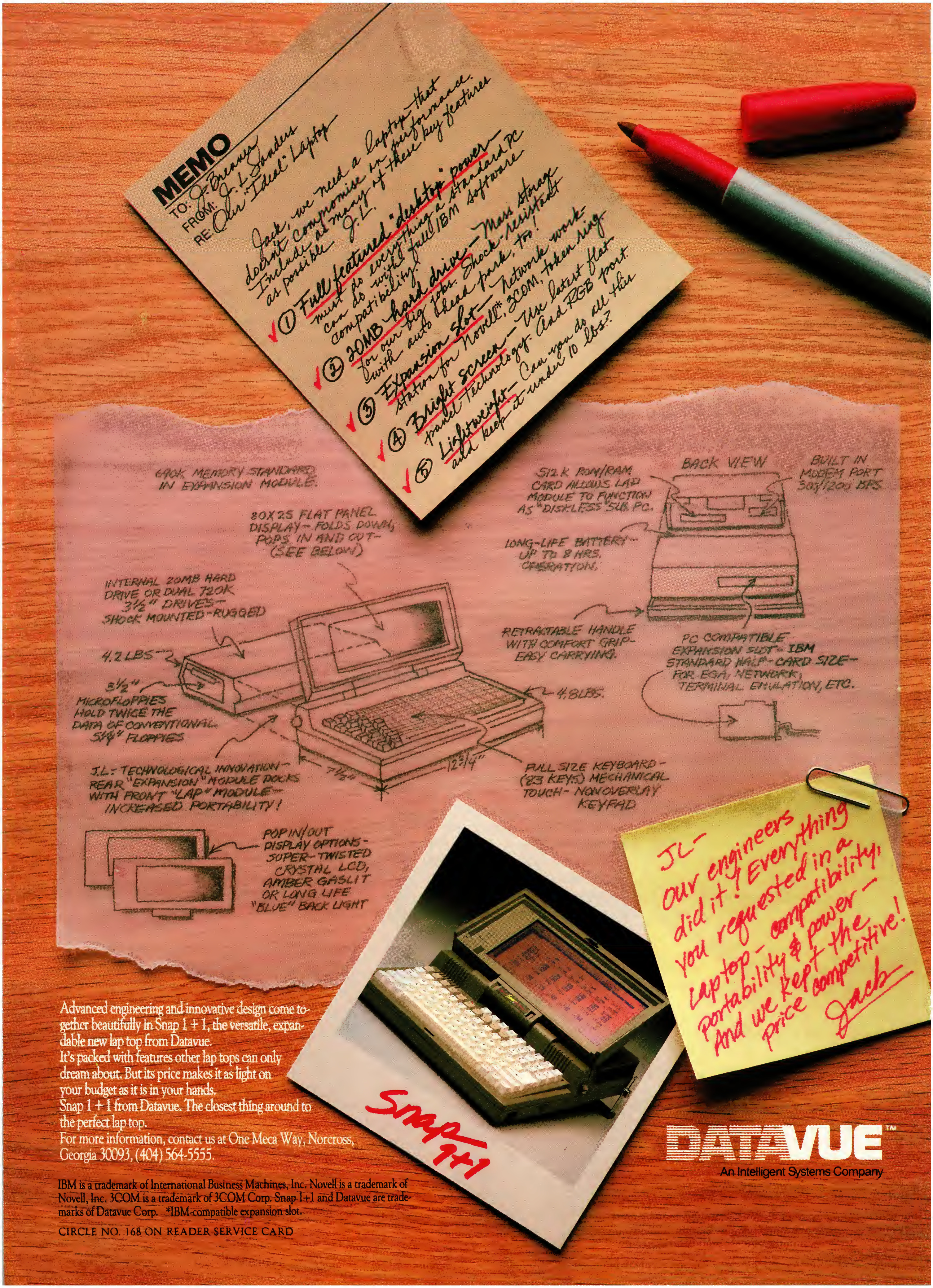
A MATTER OF DISTANCE

Many factors affect the performance of systems developed using data managers on LANs, including the category of data manager, the location of the database relative to the DBM portion of the data manager, and the type of application implemented. The speed and capabilities of the computer, available disk storage, and LAN hardware also influence overall system performance.

A relational data manager processes substantial amounts of data as it performs joins and table look-ups to produce a data table representing the result of a query. When all data manipulation must be performed by a computer at a LAN node with the data remotely located on a file server's hard disk, the considerable data movement load placed on the LAN can result in a low overall performance. Sophisticated query optimization techniques can improve the performance of relational data managers, but such methods have just begun to migrate from mainframe data managers down into the microcomputer environment.

The fact that data management systems require the manipulation of large amounts of data places severe demands on the underlying hardware system. Data must be retrieved from mass storage and presented to the data manager for processing with minimal delays. In a stand-alone, single-user system, the close coupling between the CPU and the mass-storage disk provide maximum efficiency for this operation. Also, buffering of both data and index files can substantially improve the system's performance of data access.

Many of the performance difficulties in a LAN environment stem from the fact that the DBMs of microcomputer data managers reside at the user node. The effect of the LAN is to insert additional delays and distance between the data on the file server and the processing of the data on the user computer. When data are shared in a LAN environment, the request for data first must be formulated by the user DBM, then translated into low-level system calls, and finally transmitted over the LAN to the server. The data must be retrieved from the file server disk, moved onto the LAN by the file server CPU, and retrieved from the LAN by the user DBM. The buffering of index files becomes ineffective in LAN environments because another user's data changes may affect a shared index file. To assure consistency between the data files and indexes, normally only one copy of the data is maintained at the file server.



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FROM: J. L. Sanders
RE: Our "Ideal" Laptop
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True performance breakthroughs in LAN database systems will be possible when the DBM and the DAI can be physically separated. With the DBM located at the file server, thus making it a database server, the DAI on the user computer could pass entire queries to the DBM, perhaps in SQL. The DBM on the database server then would process the query and be able to return only the answer to the query. Oracle Corporation is developing this type of database server for its LAN version. The database server will run under UNIX and will accept SQL queries from user nodes. It is expected that more such database servers will emerge with the availability of multitasking DOS.

Other data manager attributes affecting system performance include indexing methods and query techniques. Many microcomputer data managers use B+ trees for storing indexes. Retrieval of data records in index sequence requires that at least two data accesses be made for each data record read. First the index file is queried to locate the pointer to the correct data record in the data file (this actually may take more than one access to find the pointer), then the data record is retrieved. Even when some data managers store the B+ tree index in the data file header, several disk accesses may be required to retrieve a single data record.

Revelation (by Cosmos) uses hashing algorithms for storing data. Because the hash value for a record is computed at the user node and translated directly into a data record location on the file server, only one access over the LAN for data is required in most cases. The efficiency of a hashing algorithm depends upon the choice of the field, field combinations, or field portions selected as the key. A poor key choice can cause excessive collisions. Although the data manager is expected to resolve hash value collisions, each collision will require additional processing in order to locate the correct record. In general, hashing is more suited to applications, in which the system, once developed and implemented, does not undergo frequent database structure change and where ad hoc queries and analyses are not common. (For a review of Revelation, see "A Data Manager Designed for Complex Applications," Kent Phelps, February 1986, p. 160.)

Query processing must be as efficient as possible to minimize the amount of data transmitted over the LAN. Data retrieval techniques can be procedural or nonprocedural. With procedural languages, the user provides the data manager with step-by-step directions for retrieving the desired elements and may even perform the joins between files manually. In nonprocedural languages, the user specifies only the set of data to be retrieved and the data manager determines how to acquire the data. The efficiency of procedural techniques depends upon the order in which files are accessed and related to each other; the user must take into account the data structures, relationships, and existing indexes to determine the most efficient method of retrieval. With nonprocedural queries, the user has little or no control over the method used to retrieve the data, and, therefore, must rely upon the data manager to optimize query processing.

One example of data retrieval using procedural techniques would be a dBASE III PLUS program that employs DO. . .WHILE loops to extract data from multiple files. Such an application might involve an employee file with related information located in department and salary files. Such a request could incorporate tests to restrict the output to only those employees of a particular department whose employment anniversary falls within a specified month, thus producing a list of persons scheduled for annual performance reviews.

Query processing, either by procedural or nonprocedural means, must minimize the amount of data transmitted over the LAN.

If an index exists that is set up by department number on the employee file, then the entire employee file need not be read. The employee records for other than the selected department can be bypassed by seeking the first employee in the desired department and examining employee records in this index sequence only while the department number remains the one of interest. For each employee record, the date of hire is checked and other information looked up and printed only for those within the date range.

In a nonprocedural query the set of desired employees would be specified to the data manager, which would select an approach to obtain the appropriate records. In Oracle's SQL, such a query might be set up in a format similar to the following:

```
SELECT  EMPLOYEENAME,
        EMPLOYEENO, DATEOFHIRE,
        TO_CHAR(DATEOFHIRE,'MON')
        HIREMONTH,
        EMPLOYEES.DEPTNO,
        DEPTNAME, SALARY
FROM    EMPLOYEES, DEPTFILE,
        SALARYFILE
WHERE   EMPLOYEES.DEPTNO =
        DEPTFILE.DEPTNO

AND     EMPLOYEES.EMPLOYEENO =
        SALARYFILE.EMPLOYEENO
AND     EMPLOYEES.DEPTNO = 30
AND     HIREMONTH = 'JAN'
```

Note that no instructions are given to the data manager as to how to join the three tables to extract the desired results. The data manager is free to sort files, to use or create index files, or to create temporary files during the process. The user has not specified any controls that would affect the efficiency of the query evaluation.

Oracle contains an elaborate query optimizing method that analyzes the SQL statements and computes an efficient order for processing tables based upon the selection criteria in WHERE clauses connected by ANDs and table joins where indexes do or do not exist.

DATABASE DISTRIBUTION

LANs thus allow users to share a central database. The capability to use data extracted from remote databases for combination with data from local databases provides an additional dimension in data management. In large organizations, a central database may hold information common to all departments, whereas each department would store a database of information common to its departmental activity, and individual users also might have local databases for project information. It is necessary to be able to move data in all directions throughout the organizational structure.

A working definition of a distributed database is provided in *An Introduction to Database Systems, Volume II* by C. J. Date (Addison-Wesley, 1983). Date's definition is that "A database is 'distributed' if it can be divided into distinct pieces, such that for a given user access to some of those pieces is very much slower than access to others." Date goes on to specify that each node or site where a piece of the database exists constitutes a database system in its own right, with its own database, its own CPU, and its own local data manager. Control does not belong to a sin-

gle, monolithic data manager; instead, the individual data managers cooperate in a type of federation, accepting queries from remote sites and returning the requested data to the sites.

One of the goals of distributed databases is the concept of *location transparency*. The intention here is that the user specifying a query does not need to be aware of the location of the data elements accessed. For example, the SQL query

```
SELECT  PROJECTNAME, PROJECTNO,
        CLIENTNAME, CLIENTNO
FROM    PROJECTS, CLIENTS
WHERE   PROJECTS.CLIENTNO =
        CLIENTS.CLIENTNO...
```

might access a local database for project information with a look-up into a central master client list. The local data manager, but not the user, would need to know that the client list data are remotely located and how to access them. Two methods are available for accessing the client table: the local data manager may request a copy of the table to be transmitted to a temporary local file, or the local data manager may determine the list of clients needed to support the local query and request that the central data manager execute a query to extract the appropriate fields from these selected client records.

Theoretically, it would be best if no data elements were stored at more than one location, so that when a data element was updated, all accesses after the time of update would receive the latest (and, therefore, the correct) value. In most situations, however, this is not practical. Many data elements of an organizational database change infrequently, and a requirement to access this rather static data from a remote location that may be many miles away can be expensive and produce intolerable performance. It is normal to replicate some frequently accessed data elements at sites distant from the master copy to improve query performance.

These remote copies must be updated periodically, with the periodicity dependent upon the volatility of the replicated data. For example, an organization may choose to update the remote copies of its master client list daily and its master employee list weekly. System designs that support replicated data can be quite complex. Queries requesting data that are replicated should access the nearest copy, whereas processes that update replicated data must update all copies in all locations.

Clearly, a distributed database system closely models the data processing requirements of many organizations. The LAN environment provides a structure within which to implement distributed databases on a departmental scale, and micro-to-mainframe links extend the structure to include organizational data. At present, the limiting factor appears to be microcomputer and network operating system capability. Data manager applications executing on one machine need to communicate with applications executing on other machines, and they must be able to do so at a level above simple file or record transfer. An application must be able to formulate and transmit a query to a remote application that will process the query and return the result. Data managers that separate the database management functions from the query and application interface functions will be better suited to distributed data environments than the all-in-one programs currently available.

Distributed database systems, which answer the processing needs of many firms, depend upon developments in the area of connectivity.

Thus, the future of distributed database system development depends heavily upon progress in the area of connectivity. Processes that are executing on different computers, whether those machines be micros or minicomputers or mainframes, need to communicate on a process-to-process level. Applications must be able to send messages requesting information from remote applications and to receive the resulting information in a recognizable logical format. The ability to communicate at this logical level reduces unnecessary traffic on networks and communications links, thus improving performance. Ongoing endeavors in connectivity include the introduction of the IBM SNA LU 6.2 interface for interapplications communications such as IBM's APPC (advanced program-to-program communication) protocol (see "SNA Strategies," Art Krumrey, July 1985, p. 40 and "LAN Gateways," Art Krumrey and Roger Addelson, November 1986, p. 74). As connectivity technology progresses, distributed database management technology should improve as well.

CAREFUL DEVELOPMENT

Many of the currently available data managers for LANs are updated versions of existing stand-alone microcomputer programs. These products have implemented file- and record-locking features, and some also have provided file- and field-level security. However, many data managers developed specifically for the PC environment have concentrated on the user interface and ease of use, to provide a competitive edge in marketing and advertising. Upgrades to these products for use on LANs provide limited additional functionality and minimal design modification specifically oriented toward LAN performance and data integrity issues.

Data managers implemented on LANs from existing multiuser environments such as minicomputers or mainframes, on the other hand, often contain security features, sophisticated transaction processing, and audit trail capabilities. These products generally are more suited to the professional developer than to the end user because of their complexity; they lack the ease of use of the stand-alone variety.

Database systems generally are implemented on LANs to provide the capability of sharing common data. These systems require attention to design detail, careful implementation of data locking and transaction processing logic, and ongoing management of data integrity. Ad hoc end-user development of database structures may be suitable for many stand-alone applications, but effective and efficient LAN database system design and implementation still require the efforts of professional systems designers and applications developers.

Various data manager designs and implementations perform at differing degrees of efficiency in the LAN environment. Many desirable features, such as location of the database management section of a data manager at a file server to provide database server functions, await improvements in DOS to provide access to additional server memory resources and efficient multitasking of file server computers. Continuing progress in connectivity technology and the emergence of standards for logical interapplication and intersystem communications will affect the design of future multiuser and distributed database managers.

Dave Browning is vice president and co-owner of WBS and Associates, Inc., a custom database consulting firm. He is also chairman of the database special interest group for the Capital PC User Group.

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forth language

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COMPATIBILITY 286 PERFORMANCE

Portable Pacesetters

No longer do performance and portability have to be antithetical concepts when considering personal computers. Compaq and Toshiba offer machines with AT performance in portable packages.

Until recently computer users were forced to choose between convenience and portability on the one hand and performance and capacity on the other. Recent offerings from Compaq and Toshiba have changed all that. The Compaq Portable III and Toshiba 3100 pack the performance of a desktop IBM PC/AT into a convenient, carry-around package.

The following pages contain our rigorous evaluation of these products as AT-class machines. Both computers were put through the same compatibility and performance tests as all the other machines reviewed in our series on AT compatibles. We at *PC Tech Journal* went to work on the Portable III the day it was announced to produce the thorough review beginning on p. 76; this is followed on p. 86 by a close look at the T3100, written by Ashley Grayson and John Vornholt, who as authors of a guide to portables are no strangers to this genre of computers.

The Compaq and Toshiba machines do not merely offer an 80286 processor in a small box. The Portable III's processor runs at 8/12 MHz, 50-percent faster than that of the AT's processor; the T3100 runs at 4/8 MHz. Standard with both machines are 640KB of memory (internally expandable to 6.6MB on the Portable III and 2.6MB on the T3100), and a high-capacity diskette drive (the Portable III drive uses 1.2MB, 5¼-inch media; the T3100, 720KB, 3½-inch media). For additional mass storage Compaq offers a 20MB or 40MB hard disk; Toshiba has a 10MB hard disk. These machines are definitely capable of performing tasks other than executive notetaking.

Compaq and Toshiba have taken different approaches to packaging their computers. The Portable III is a convenient size that can be operated almost anywhere that AC power (and a desk or tabletop) is available. With its nearly full-sized keyboard and height-adjustable screen, it will likely be used in offices as much as it is used on the road. The T3100 is very small—at some sacrifice in keyboard layout and overall AT compatibility; it is the size of a small briefcase and can be used wherever AC power is available.

The Compaq Portable III and Toshiba 3100 provide unequaled convenience and performance in practical, portable packages. It seems quite probable that at least one (or more likely several) of each soon will be found in an office or under an airline seat near you.

—Jim Shields

PHOTOGRAPH • MARC DAVID COHEN

Portable III

From the series that first made a name for Compaq comes a portable powerhouse that does not sacrifice high performance to achieve its smaller size.

JIM SHIELDS

The latest portable computer from Compaq Computer Corporation, the Portable III, is significant both for what it is and for what it is not. It is *not* a lightweight laptop computer. Although it can sit on a user's knees in a pinch, performing such a balancing act with an 18-pound, $3,999 computer is neither wise nor comfortable. It *is* a full-function, AT-compatible computer. In fact, with its 12-MHz 80286 microprocessor and high-performance hard disk the Portable III provides all the personal computer performance that an individual is likely to need in or out of the office. (*PC Tech Journal* reviewed Compaq's desktop models, the Deskpro 286 and Deskpro 386, as part of this series on AT compatibles in "Compaq Deskpro 286," Steven Armbrust and Ted Forgeron, August 1986, p. 80 and "The New Standard," Steven Armbrust and Ted Forgeron, March 1987, p. 48.)

Three Portable III models, distinguished only by their hard-disk drives, are available. The entry level Model 1 does not come with a hard disk; the Model 20 has a 20MB hard disk; and the Model 40 has a 40MB disk. Features and options available with the three models are listed in the accompanying sidebar, "Portable III Vital Statistics." The Portable III and any Compaq options or accessories purchased from and installed in it by Compaq or its authorized dealers have a one-year warranty.

The test machine for this review was the middle-of-the-line Model 20, equipped with the standard 640KB of memory, 5¼-inch, 1.2MB diskette drive, 20MB hard disk, integrated high-resolution, dual-mode plasma display with height and tilt adjustments, asynchronous communications port, parallel printer port, and external RGB monitor interface. Optional equipment included an 8-MHz 80287 numeric coprocessor, Compaq Enhanced Color Graphics Board, and Compaq Color Monitor. Photo 1 shows the Portable III set up with the color monitor.

LUNCHBOX COMPUTER

The Portable III is notable for its small size. Even with the optional expansion unit attached and the keyboard in its operational position the unit occupies only 16-by-17 inches of desk area, 20 percent less than the size of the IBM PC/AT system unit alone. Weighing in at 18 pounds (20 pounds with a hard disk), this computer can be moved wherever it is needed without undue physical strain on the mover.

When packed up for transporting, the outside appearance of the Portable III is closer to that of a lunchbox than a computer. The keyboard is held against the front of the system unit by a plastic flange (which also serves as a holder for the keyboard cord) and two movable plastic tabs. In this position the keyboard protects the plasma display.

Set up of the computer requires only the inward movement of the two plastic tabs to let the keyboard swing down into its operational position. This action uncovers the Portable III's display, which is attached to the front of the system case. To provide for more comfortable viewing, the display can be raised 3½ inches and then tilted up to 20 degrees. An optional desktop pedestal raises the system unit approximately two inches, as well as offering additional tilt adjustment.

Though small in size, the Portable III is a full-function AT compatible. Its Intel 80286 microprocessor runs at either 8 or 12 MHz, and an 8-MHz 80287 numeric coprocessor is an option. Compaq provides high-performance memory and mass storage components to complement the high-speed 80286. Minimum memory is 640KB; 6MB of extended memory can be added using a Compaq miniboard, measuring about 3½ inches square.

The Portable III holds up to two data storage devices. All models come standard with a one-third-height, 5¼-inch, 1.2MB diskette drive that reads both 360KB and 1.2MB diskettes and writes 1.2MB diskettes. The second data storage device may be either a one-third-height 20MB or 40MB hard disk. The optional hard disks have integrated controllers, extremely quiet operation, and an average access time of less than 30 milliseconds (ms). An optional 360KB diskette drive is available as a replacement for the 1.2MB drive. The diskette and disk drives are mounted vertically on the right side of the system unit as viewed from the front (see photo 1). All drives are shock mounted and designed to withstand the rigors of rough operation and transportation.

Rounding out the Portable III's capabilities as a fully functional, integrated computer is the Compaq internal modem, a Hayes-compatible 300/1200-bps unit. Two RJ11 telephone jacks replace a small, removable panel on the right side of the system case to allow a telephone set and line to be connected to the internal modem.

The detachable keyboard of the Portable III has full-size keys, and, with

the exception of the 10 function keys located in a row across the top, the layout is the same as the standard IBM AT keyboard (see photo 2). The keyboard has the traditional Compaq soft feel and lighted NumLock, CapsLock, and ScrollLock keys. The computer produces a simulated key click via the system speaker. The volume of the click can be controlled with the Ctrl-Alt-+ or Ctrl-Alt– key combination. (The plus and minus keys on the numeric pad must be used for this purpose.)

Because the keyboard cord plugs into the system unit using a standard DIN-type connector, users may substitute other keyboards. Full support is provided for both the Compaq 84-key and (though not documented in the operations guide) the Compaq enhanced 101-key keyboards. However, the opening to the Portable III's keyboard connector is too small and the connector is recessed too far into the system case to accommodate the plugs provided with some keyboards—in particular, IBM's standard and enhanced AT keyboards. A third-party keyboard cord with a smaller plug housing can be used to connect the enhanced keyboard. Because the Portable III's keyboard socket is recessed almost two inches inside the system case, the user must either grasp the flexible cord or use a tool to grasp the plug itself in order to it get into the socket.

Unlike most AT-compatible computers, the Portable III does not provide a key-lock switch. This is not likely to be a shortcoming when the machine is used as a portable computer; however, for some desktop applications the lack of this switch may be an issue.

Three green LED indicators are located at the top right of the system unit. The topmost is a power-on indication. The next two, labeled 1 and 2, are lit when their corresponding data storage devices are active; devices 1 and 2 are the diskette and hard-disk drives, respectively. The diskette drive also has an LED indicator, visible from the side of the system unit, that glows orange when operating in 360KB mode and green when in 1.2MB mode. The optional 360KB drive's indicator glows orange when that drive is operating.

The power-cord connector and power switch are located on the right rear of the system unit, as shown in photo 3. The system power supply provides 145-watts steady-state, 160-watts peak, and features automatic line selecting between 110VAC/60-Hz and 220VAC/50-Hz electrical power for international operation. Unfortunately, no provision is made for storing the power cord in the system unit during transport.

Connectors for the external RGB monitor interface, asynchronous communications adapter (serial port), and parallel printer port are located on the rear of the system unit next to the power connector and switch. The serial and parallel port connectors are identical to those used on the AT; the serial port has a 9-pin, D-shell, male connector, and the parallel port has a 25-pin, D-Shell, female connector.

The Portable III builds considerable flexibility into the serial port configuration. The serial port and the optional internal modem can be configured in several different ways by changing the jumpers on the motherboard. For example, either the serial port or the internal modem can be configured as COM1 or COM2, or the interrupt level can be changed. In addition, the serial port can be disabled if the user desires. The parallel port is configured as LPT1, but it also can be enabled or disabled simply by changing a jumper position.

The RGB monitor interface is provided via a 9-pin, D-shell female connector. A complete emulation of the RGB functions of the IBM Color Graphics Adapter (CGA) is provided.

PLASMA DISPLAY

The Portable III's display is an orange, 10-inch, dual-mode plasma unit. A brightness control knob is located on the lower right of the display. This unit in conjunction with its video controller miniboard provides high-resolution text and three graphics resolutions (640-by-200, 320-by-200, and 640-by-400 pixels). The high-resolution text mode is compatible with the IBM monochrome adapter; the two lower graphics resolutions are compatible with the CGA, and the third with the AT&T 6300.

The video controller board contains 32KB of video memory and a RAM-based character generator. Two character sets, referred to as the main and alternate sets, may be stored on the board at the same time. These character sets are loaded using the DOS terminate-and-stay-resident (TSR) utility CHARSET, which is provided by Compaq. CHARSET also loads the character sets into the optional Compaq Enhanced Color Graphics Board if installed. When operating at normal intensity, the display cannot highlight characters, but it can display them in reverse video, underlined, or half intensity; it also can display the corresponding character from the current alternate character set. Table 1 shows the MODE attribute commands that determine the treatment of highlighted text.

MODE ATT=TOG is quite useful in that it allows normal text to be highlighted and treats highlighted text as if it were normal text. Using this feature with the MODE ATT=HALF command allows bold text to be displayed more brightly than surrounding text; however, the resultant half-lit normal text may not be sufficiently visible in a bright office environment. In such cases the more practical solution may be to load THINUS, a single-dot font, as the

COMPAQ PORTABLE III VITAL STATISTICS

Model 1: $3,999
640KB memory
Serial and parallel interfaces
High-resolution plasma display
RGB interface
Realtime clock
1.2MB diskette drive

Model 20: $4,999
All features of model 1 plus:
20MB hard disk

Model 40: $5,799
All features of model 1 plus:
40MB hard disk

Internal memory capacity
640KB; can be increased by 6MB of extended memory

Available slots (in expansion unit)
16-bit: 2

Options Available
20MB hard disk: $1,299
40MB hard disk: $2,199
360KB diskette drive: $225
Compaq internal modem: $399
Expansion unit: $199
Internal memory expansion board: $225
512KB memory expansion kit: $250
2MB memory expansion kit: $1,299
8-MHz 80287 coprocessor: $349
Compaq Color Monitor: $799
Compaq Enhanced Color Graphics Board: $599
Desktop pedestal: $89
Carrying case:
Nylon: $89
Leather: $225
MS-DOS/BASIC:
Version 3.1: $85
Version 3.2: $95
Technical Reference Guide: $99

PHOTO 1: *Desktop Color Configuration*

PHOTO 2: *Keyboard Comparison*

PHOTO 3: *Rear Panel and System Case*

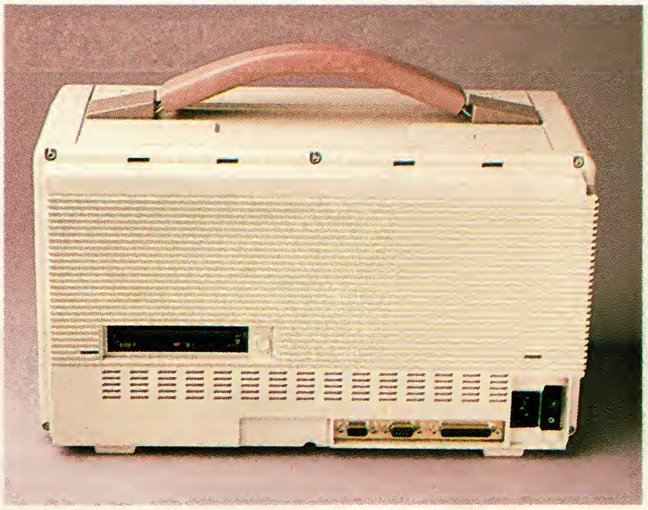

PHOTO 4: *Miniboard Bays*

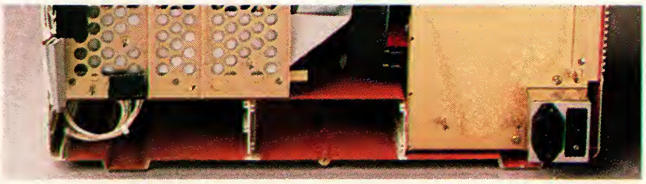

PHOTO 5: *System Board and Video Controller*

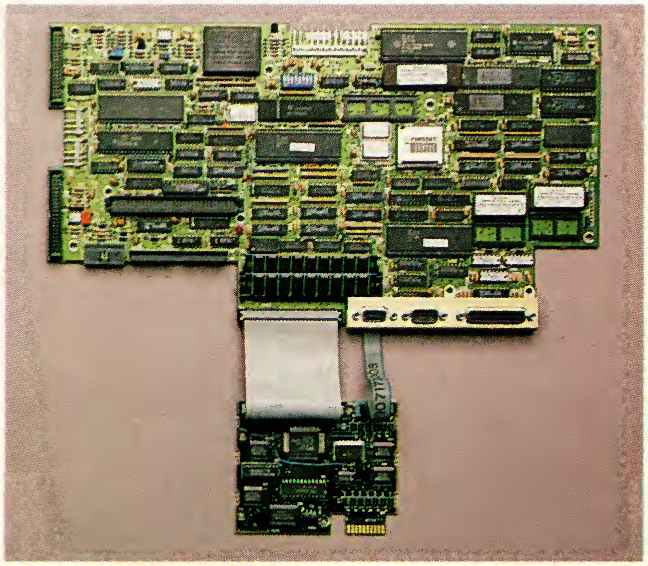

PHOTO 6: *Expansion Unit*

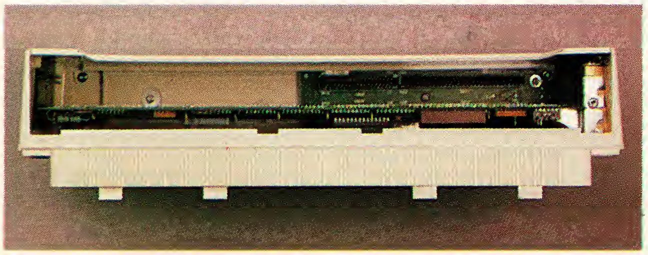

Photo 1: Shown here with a Compaq Color Monitor and the expansion unit attached, the Portable III occupies 20-percent less desk space than the AT system unit alone.

Photo 2: The Portable III keyboard (top) matches the standard AT keyboard in most respects; the most obvious difference is the location of the function keys across the top.

Photo 3: The rear panel features connectors for the RGB display interface and serial and parallel ports on the bottom right, and the 96-pin bus connector for the expansion unit.

Photo 4: The internal modem and memory expansion miniboards are mounted in the grooves on the left. The video controller mounts in the grooves in the upper right.

Photo 5: The system board is mounted vertically in the back of the system unit. The video controller is mounted behind the system board parallel to the bottom of the case.

Photo 6: The expansion unit provides two AT-type, 16-bit slots that operate at 8 MHz. It is attached to the rear by inserting the tabs and pressing the bar at the bottom.

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main character set and FONTUS, a double-dot font, as the alternate character set (both are provided on the Compaq User Programs diskette). This is accomplished using the command

CHARSET MAIN=THINUS ALT=FONTUS

Path names must be used as appropriate. This, in combination with a MODE ATT=ALT command, makes bold characters appear bolder than normal characters without decreasing the intensity of the normal text. Underlined text also can be displayed, so the user can enjoy a reasonable degree of what-you-see-is-what-you-get text display.

A screen-saver feature is also provided. If no keyboard or other activity takes place for a specified number of minutes (between 1 and 63), the screen is blanked. Entering a value of 0 disables this feature. The screen is reactivated by pressing any key. The inactivity time before screen blanking as well as the default treatment of highlighted text can be saved in the system's battery-maintained memory using the SETUP program on the Compaq User Diagnostics diskette. These two items also can be changed temporarily from within a program by activating the previously loaded TSR program ADAPT, which is supplied on the User Programs diskette.

For compatibility with software and any other video adapters that could be installed in the expansion unit, the plasma display can be operated in either CGA or monochrome mode, with the video buffer located beginning at B8000H and B0000H, respectively. A switch on the system board determines into which mode the video controller is placed whenever the system is initialized. This, combined with the previously described video features of the Portable III, makes the machine very AT compatible in its video operations even though the plasma display is significantly different from the CRT displays that are normally used with the AT.

The RGBI output of the video controller may be used to drive a standard external color monitor. The MODE ,E command directs screen output to the external display and disables the internal display. MODE ,I disables the external display and directs screen output to the internal display. The key sequences Ctrl-Alt-< and Ctrl-Alt-> perform the same respective functions.

TABLE 1: *MODE Screen Attribute Commands*

COMMAND	PARAMETER	ACTION FOR HIGHLIGHTED TEXT
MODE ATT=	ALT	Use character from alternate set
	HAL	Use half intensity
	REV	Use reverse video
	UND	Underline
	IGN	Display as normal text
	TOG	Display as normal/highlight normal
MODE UND=	ON	Enables underlining
	OFF	Disables underlining
MODE SCR=	n	Minutes until display is blanked (0 – 63, 0 disables feature)
MODE SEL=	CGA	Display controller emulates Color Graphics Adapter
	MDA	Display controller emulates monochrome adapter

Various MS-DOS MODE commands are available to manage the special screen attributes that are provided by the Portable III's dual-mode plasma display.

FULL POWER

Although the Portable III's small size and plasma display are distinctive, performance is its most important attribute. The speed of its 80286 may be set using the MS-DOS MODE SPEED command, with an argument of FAST for 8-MHz operation, HIGH for 12 MHz, and AUTO for 8-MHz operation during diskette access and 12 MHz otherwise. A switch on the system board determines whether SPEED is set to FAST or AUTO when the system is initialized. At system initialization, one computer-generated beep indicates a FAST setting and two beeps indicates AUTO. The CPU also can be switched from HIGH or AUTO to FAST operation and vice versa by pressing Ctrl-Alt-\. This method is accompanied by the same beeping sequence just described.

The Portable III does not contain any conventional expansion slots within the system unit itself. The memory expansion board, video controller, and internal modem are all approximately 3½-inch square miniboards connected to the system board and mounted in grooves that are molded into the system case (see photo 4).

The power switch and bottom of the 145-watt power supply can be seen on the right of photo 4. The video controller board is mounted to the left of the power supply; the hard-disk drive is located to the right of the video controller. The hard-disk controller, which is packaged with the drive, connects to a host adapter on the system board that provides data buffering and I/O address decoding functions.

The inside of the Portable III's system case is coated to prevent radio frequency interference (RFI); the inside of the reviewed early production expansion unit was not, but Compaq plans to coat all full-production expansion units. It is also interesting to note that the interior of the later production models have additional shielding over the main circuit board that was not present in the model reviewed here.

The system board (photo 5) is mounted vertically in the back of the system unit. The 80286 microprocessor is mounted just to the right of center in a leadless chip carrier. The socket for the 80287 is just above the 80286.

The ROM devices that contain the system BIOS are the two chips with white labels to the lower right of the 80286. Below them are two empty sockets reserved for future ROM expansion. The base system RAM is located in the lower center of the system board. Bank 0 of memory consists of two socketed 256KB modules, each composed of nine 256K-by-1-bit RAM devices. Bank 1 consists of four 64K-by-4-bit RAM devices soldered on the system board. Both banks use dynamic RAM devices with a response time of 100 nanoseconds.

To achieve the small size of the system board, Compaq uses four gate-array devices, known as application-specific integrated circuits (ASICs). One is used for clock and bus control, another for the memory map, a third for memory and speed control, and the fourth acts as the diskette-drive controller. The video controller miniboard, shown in photo 5, is mounted parallel to the bottom of the system unit and is connected to the system board by the ribbon cable just below the 256KB memory modules.

PORTABLE INSTALLATION

Installing the Portable III is as easy as removing it from its shipping box, lowering the keyboard to its operating position, replacing the cardboard retainer in the diskette drive with a bootable diskette, attaching the power cord, and turning on the computer. Of course, users of hard-disk models will load soft-

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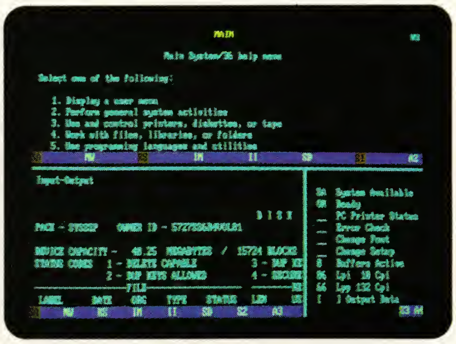
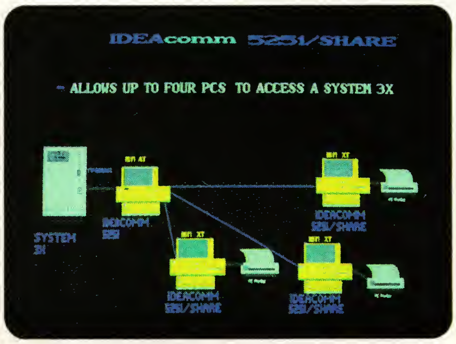
IBM 5292 Model 2 graphics



Windows with multiple host sessions

IBM 3180 terminal emulation



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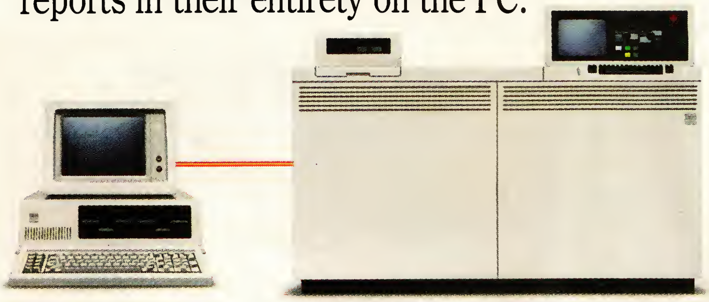

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ware and perhaps run SETUP to change system initialization options, but for an AT-class computer the installation procedure is a pleasant surprise.

Hardware that can be installed in the Portable III falls into two categories: devices for the system unit and those for the optional expansion unit. To install equipment or change switches and jumpers in the system unit, it should be placed face down on a flat surface (with the keyboard attached to protect the plasma display) so the back can be removed. Six Torx T-15 screws hold on the back cover: four-inch screws in each corner and half-inch screws on the top and bottom. Placing a small object under the system unit so that it sits level on the work surface aids in the process of removing and replacing these screws.

With the back of the system unit off, the user has unobstructed access to the system board. Installing an 80287 coprocessor is merely a matter of inserting the chip and then running the SETUP program. The system is also designed for easy installation of additional RAM and the Compaq internal modem. The expansion RAM miniboard and the internal modem miniboard are plugged into dedicated slots on a small memory/modem interface board, which is connected to the system board. Two switches on the system board indicate the size of the memory banks on the expansion board (either 512KB or 2MB). Two jumpers on the system board show the total amount of extended memory installed on the system. Up to three banks can be installed on the memory expansion board.

While the installation of options in the system unit is easy, installation of boards in the expansion unit often is not. Shown in photo 6, the expansion unit is a plastic case that snaps on to the back of the system unit by inserting the tabs at the top and firmly pressing in the bar at the bottom of the expansion unit. It should be attached and detached only when system power is turned off. Care must be taken to line up the grooves in the two units in order to assure a snug fit; otherwise a faulty electrical connection may result, leaving the system partially or totally unaware of the boards that are installed in the expansion unit.

The unit contains two AT-type, 16-bit expansion slots that operate at 8 MHz. Each board installed in the expansion unit is secured by a Torx T-10 screw. An on-board crystal oscillator provides the 14.318-MHz clock signal required by some video controller boards. The expansion unit is a small package that does not unduly increase the overall size of the computer. It accommodates two AT-style, full-sized adapter boards, but has little spare room for the hands that are trying to install them. If the board to be installed is the tiniest bit too long, or the mounting bracket is a bit askew, the process can easily take a half-hour or more.

The lack of room, however, is only half of the inconvenience if the board being installed requires that switches or jumpers be changed on the system board. (This is the case for the installation of color video controllers and extended memory boards.) The back of

Swapping boards in and out of the Portable III will never be the same as performing those operations on a desktop AT or compatible.

the system unit must be removed in order to change switches or jumpers, then replaced because the expansion unit attaches to it. The system then can be powered up and tested. If a problem occurs, as is often the case, the installer may have to remove the board from the expansion unit, or if that does not solve the problem, he may have to remove the expansion unit and the system unit cover again in order to get to the system board. Needless to say, this can go on for some time.

Under such circumstances, it will doubtless be tempting to attach the expansion unit to the system unit without replacing the cover, but this is not recommended. The sole means of support for the expansion unit would be the 96-pin bus connector located near the left center of the rear of the system unit. This treatment would subject the connector to undue strain, perhaps causing the expansion unit to become separated from the system unit, with possible electrical and mechanical damage to the system, the expansion unit, and the boards in it.

All this inconvenience is not to say that the expansion unit is not functional once installation is complete. However, swapping boards in and out of the Portable III will never be the same as performing similar operations on a desktop AT or compatible.

COMPANION SOFTWARE

MS-DOS 3.1 and 3.2 and GW-BASIC 3.0 are available at extra cost. Compaq's MS-DOS 3.1, used for this review, provides the features of IBM's PC-DOS 3.1 plus additional programs such as CMPQADAP, a utility for modifying the keyboard driver, and ENHDISK.SYS, a disk driver that allows a hard disk to be accessed as multiple volumes.

As with the Deskpro 386, Compaq provides a User Programs diskette that contains additional and replacement DOS utilities that are specifically for the Portable III. These include the plasma display utilities and fonts described earlier. Unfortunately, as is the case with the Compaq Deskpro 386, the user is not told in the *Operations Guide* or the *MS-DOS Reference Guide* that these utilities exist and must be installed on the system along with (and in some cases, in place of) DOS utilities. Compaq apparently plans to remedy this situation with version 3.2 of MS-DOS.

Compaq also provides a User Diagnostics diskette with the Portable III that contains the TEST and SETUP programs along with short explanations of their use. These programs perform the same functions as IBM's standard diagnostics. One notable feature of TEST is that when executed it advises the user to test any non-Compaq video controller board using that board's diagnostics. Further, it prevents the use of the corresponding Compaq video board test by deleting it from the diagnostics menu. TEST is also particular about the type of computer it runs on. An attempt to execute it on a non-Compaq computer results in the program's termination, with a message saying that it is for use only on Compaq computers.

The *Operations Guide* for the Portable III provides clear, concise explanations of the operation of the system and useful information on available options. It omits an important explanation, however. The functions of the board's bank of eight switches and the most common set of jumpers are covered, but the individual switch and jumper settings are not described. Compaq provides a description of these settings on the rear panel of the inside of the system unit, which is a good idea in and of itself, but the settings should be provided in the *Operations Guide* as well. This will become particularly evident if the description is omitted from the inside rear panel, as was the case with the review unit. This information is available at extra cost in the *Technical Reference Guide*, a very detailed and informative manual available for $99.

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FULL-FUNCTION TESTING

The Portable III was evaluated using the two sets of tests used on all the systems reviewed in *PC Tech Journal*'s series on AT compatibles. First, commonly used hardware and software were installed and used to assure AT compatibility. Then the *PC Tech Journal* compatibility and performance tests were run and the results compared with the 8-MHz IBM AT. (For a full explanation of the tests, see "Out from the Shadow of IBM," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52 and "Updating the Evaluation Suite," Ted Forgeron, Paul Pierce, and Steven Armbrust, March 1987, p. 70.)

All of the hardware products tested in the Portable III worked correctly. These included an 8-MHz 80287, an Intel Above Board with 3.5MB of memory, a Hayes Smartmodem 1200B and 2400, Microsoft serial and bus mice, and the Compaq Enhanced Color Graphics Board and Color Monitor.

In order to use the Compaq Enhanced Color Graphics Board with the Portable III, switch 7 of the system board switch block must be turned off to indicate that the plasma display adapter is to be placed in monochrome mode when the system is initialized. Neglecting to make this change results in an incomprehensible image on the plasma display. Once the graphics board has been properly installed (including setting the switches on the mounting bracket to indicate that it is the secondary video adapter), it can be selected using the MS-DOS MODE CO80 command. The plasma display adapter can be selected again by entering the MODE MONO command.

Software tested on the Portable III included Borland's Reflex 1.1, SideKick 1.56A, SuperKey 1.15A, and Turbo Lightning 1.01A. These programs were used to test the Portable III's graphics capabilities and its behavior with TSR packages. DCA/Crosstalk Communications' Crosstalk XVI 3.61 and Hayes' Smartcomm II were run with the two Hayes modems to check communications capabilities. Intel's QUIKMEM2 RAM disk and Living Videotext's Ready! 1.00d tested expanded memory, while IBM and Compaq versions of VDISK tested extended memory. Microsoft Windows and Word were used to test graphics capabilities and mice support. Fifth Generation Systems' Fastback tested direct memory access, and various modules of the IBM Advanced Diagnostics were used to perform general system testing.

With the exception of SuperKey 1.15, the TSR programs ran as advertised. SuperKey's problem was due to the Portable III's support for an enhanced keyboard, even though it does not have one itself. When used on machines providing enhanced keyboard support (including the IBM AT), version 1.15 of SuperKey forces the user to press Ctrl-M instead of Enter, Ctrl-H instead of Backspace, and so forth. (Version 1.16A works fine with the Portable III, however.) The important point here is that Portable III users may have to obtain enhanced keyboard versions of some of their software.

The test with Reflex dramatically demonstrated the advantage of the plasma display's 640-by-400 pixel resolution. The Reflex installation program allows the user to choose among several different display drivers, and while Reflex displays are acceptable using the standard CGA driver, achieving the crisp 640-by-400 resolution was simply a matter of installing the AT&T 6300 driver. The same resolution was achieved with Windows by specifying the AT&T 6300 driver. With the 12-MHz processor speed and the RAM disk that can be conveniently installed using extended memory, the Portable III is the smallest, fastest Windows PC around.

With its 12-MHz processor speed and a RAM disk installed, the Portable III is probably the smallest, fastest Windows PC around.

The combination of high-resolution graphics and TSR programs presented some problems. When SideKick was configured to be used over graphics and invoked with Reflex and the plasma display in CGA mode it worked fine. When it was invoked with Reflex in the 640-by-400 mode, the plasma display was completely incomprehensible when control was returned to Reflex.

The current version of SideKick is known to leave behind color patterns when invoked from within EGA graphics applications. This problem is not difficult to clear up if a key sequence is available to direct the application to rewrite the screen. The Portable III's plasma display is so totally unreadable after SideKick use, however, that this type of workaround is not practical unless it can be performed blind.

Microsoft Word was able to take advantage of the plasma display's high resolution only in text mode. Word does use high-resolution graphics on the AT&T 6300, but it apparently could not determine that the 640-by-400 mode was available on the Portable III.

Some difficulties were also encountered when using Crosstalk XVI version 3.61 on the Portable III. It worked as expected with the Portable III running at 8 MHz, but refused to dial when running at 12 MHz. A call to DCA/Crosstalk Communications yielded a replacement diskette that worked correctly at either CPU speed. Crosstalk users with an XTALK.EXE file that has a creation date before 7/22/86 should obtain either a patch for their current diskette or a replacement diskette from the manufacturer in order to run Crosstalk using the 12-MHz CPU speed. The update is available at no charge. Smartcomm II ran without incident at either speed.

The Portable III also was tested using the five *PC Tech Journal* compatibility and performance programs: ATBIOS examines the BIOS and BIOS data areas; ATKEY tests AT keyboard compatibility; ATPERF measures CPU and numeric coprocessor clock rates, in addition to memory access times; ATFLOAT measures typical floating-point operation times; and ATDISK evaluates hard-disk performance. Table 2 lists the results of these tests.

ATBIOS indicated the standard use of the ROM BIOS data area. It displayed a Compaq copyright date of 01/19/87.

ATPERF demonstrated that the Portable III performs instruction fetch and RAM and ROM access about 1.5 times faster than an 8-MHz AT. It showed that the effective clock rate of the CPU is 11.8 MHz, rather than the expected 12 MHz. The 11.8 figure, which was confirmed by hardware measurements, results because the entire system runs at 8 MHz during the memory refresh cycle, regardless of whether the CPU speed is set to 8 or 12 MHz. Thus, when set to 12 MHz, the CPU runs at 8 MHz for 5 percent of the time and at 12 MHz for 95 percent of the time, for an effective clock rate of 11.8 MHz. Both ATPERF and hardware measurements indicated an 8-MHz clock rate when the CPU speed was set to 8 MHz.

Expanded memory access occurs in the same amount of time using memory on the Portable III's 8-MHz expansion bus as it does on the AT. Video write performance using the Portable III's internal video controller in CGA mode is almostly exactly the same as that of a CGA installed in the AT. More video

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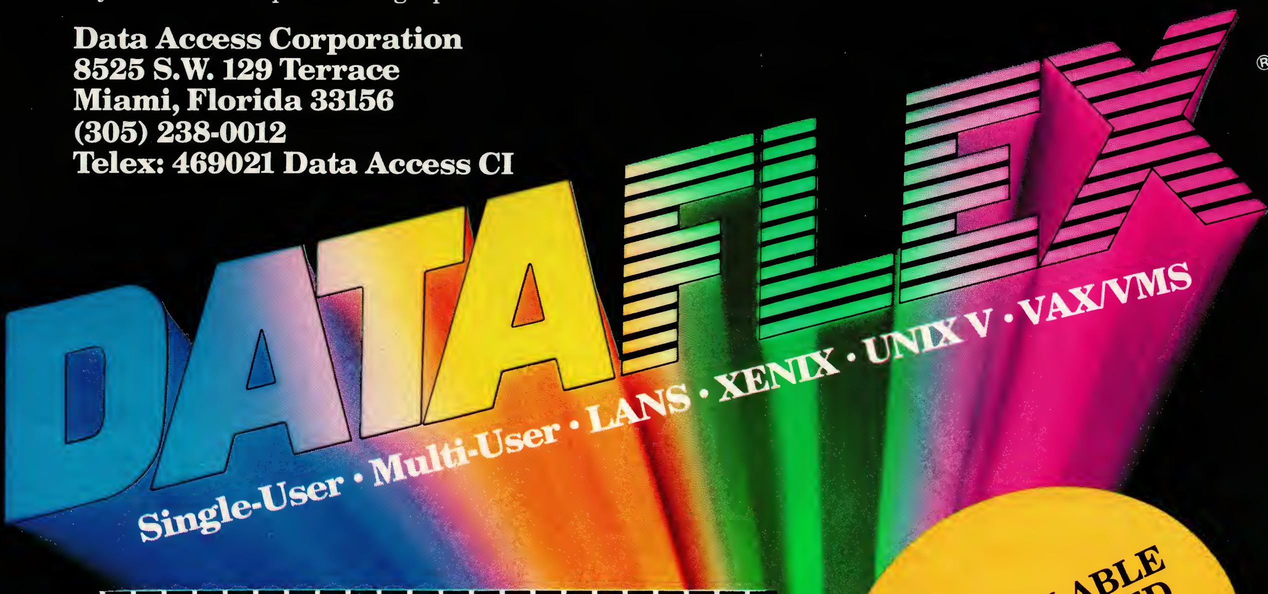

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write and EMM read and write wait states are observed with the Portable III because of its 12-MHz CPU speed, as compared to the 8-MHz AT.

ATKEY verified keyboard compatibility. This was also verified using the IBM Advanced Diagnostics. Both the IBM enhanced keyboard (with a Compaq cord) and the Compaq enhanced keyboard worked correctly.

ATFLOAT, which measures the time taken to perform 100 multiplies on a 20-by-20 matrix and compares that to time required to perform the same operation on an 8-MHz AT, indicated that the Portable III performs this application 1.4 times faster than the standard AT. Although floating-point operations take up the majority of the time required to perform this operation, the CPU time required for looping through the matrices is included as well.

ATDISK indicated that the Portable III's hard disk is indeed a speedy performer with an access time of less than 30 ms and an effective transfer rate approximately 1.5 times that of the AT.

PORTABLE POWERHOUSE

Compaq chose not to compromise compatibility and high performance for small size in the Portable III. This is a powerful, integrated computer system, but it is not a magic answer to all computing needs. Even with the optional expansion unit it is not as expandable as a desktop AT. Furthermore, the expansion unit, although functional, is not very practical. Leaving it attached when transporting the system makes for a very awkward package; removing it usually means running SETUP and carefully reattaching it later. For better system portability, the system case should provide storage space for the power cord. The plasma display needs to be brighter to be really effective in brightly lit environments. Finally, the Portable III could stand to shed a few pounds.

While the Portable III may not be the lightest or smallest portable computer around, it is certainly the fastest. Its combination of size and speed may even encourage the development of smaller desktop computers. Many people who cannot find room on their desk for a computer could surely clear a space for one with the size and performance of the Portable III.

Compaq Computer Corp.
2033 FM 149
Houston, TX 77070
713/370-0670
Portable III
CIRCLE 357 ON READER SERVICE CARD

TABLE 2: *Compatibility and Performance Tests*

	8-MHz AT, 30MB DISK[a]	PORTABLE III, 20MB DISK
ATBIOS		
ROM BIOS date	11/15/85	01/19/87
ATPERF		
Average RAM instruction fetch (μs)		
BYTE	.250	.17 (150)[b]
WORD	.403	.27 (150)
Average RAM read time (μs)		
BYTE	.401	.28 (144)
WORD	.401	.28 (144)
Average RAM write time (μs)		
BYTE	.401	.26 (155)
WORD	.401	.26 (155)
Average ROM read time (μs)		
BYTE	.401	.28 (144)
WORD	.401	.28 (144)
Average CGA video write time (μs)		
BYTE	1.208	1.18 (103)
WORD	2.415	2.35 (103)
Average EMM read time (μs)		
BYTE	.402	.40 (100)
WORD	.402	.40 (100)
Average EMM write time (μs)		
BYTE	.402	.40 (99)
WORD	.402	.40 (99)
CPU clock rate (MHz)	8.0	11.8 (147)
Numeric coprocessor clock rate (MHz)	5.3	7.9 (148)
Refresh overhead (%)	7.1	5.7
RAM read wait states	1	1
RAM write wait states	1	1
ROM read wait states	1	1
Video write wait states (CGA)	8	11
EMM read wait states	1	2
EMM write wait states	1	2
ATFLOAT		
Performance as percentage relative to AT	100	140
ATDISK		
Sectors/track	17	17
Heads	5	4
Cylinders	731	613
Total space (million bytes)	31.81	21.34
Track-track seek time (ms)	6.0	6.6
Average seek time (ms)	37.1	26.7
Effective transfer rate (KB/sec)	170.1	255.0
DOS file I/O (sec)	7.3	8.5
Interleave	3	2

[a] *The figures for the IBM AT are the average results from several machines, whereas the results from the Compaq Portable III are taken only from the review sample model.*
[b] *Figures shown in parentheses represent the relative performance expressed as a percentage compared with* PC Tech Journal's *baseline machine, the 8-MHz, 30MB AT.*

The Portable III's well-matched 80286 processor, 80287 numeric coprocessor, and memory enable it to provide 1.5 times the internal performance of the 8-MHz IBM AT, while maintaining compatibility and providing reasonable portability. The higher number of video write wait states is due to the processor's higher speed.

Toshiba 3100

Although it may look like an entirely different species, the Toshiba 3100 is indeed an AT compatible that is packaged in a very small box.

ASHLEY GRAYSON and JOHN VORNHOLT

As if to bear out the adage about good things coming in small packages, Toshiba has produced the smallest and most portable AT compatible available today. Packed into a sleek 12-by-14-by-3-inch profile and weighing 15 pounds (see photo 1), the Toshiba 3100 provides a built-in plasma display, 10MB hard disk, and a 3½-inch, 720KB diskette drive, as well as an 80286 processor and 640KB of memory. With this remarkable product, Toshiba challenges most preconceptions that users have about both AT-compatible and portable computers.

Toshiba is one of those Japanese companies that prefers to compete on the basis of quality and innovation rather than price. It makes some of the best televisions, monitors, and dot-matrix printers in the world, none of which could be considered low cost. Priced at $4,199, the T3100 is no exception, but it benefits from Toshiba's previous experience with two less expensive laptop portables, the T1100 and T1100 Plus.

The T3100 is priced competitively with the Compaq Portable III, the computer with which it is most likely to be compared. Both machines compete for the buyer who wants to take an 80286-based computer on the road. While the Portable III is a higher performance computer than the T3100, it also weighs a few pounds more and has a one-third larger footprint. (The Portable III is reviewed in this issue, p. 76.)

As a dedicated developer's machine, the T3100 will probably not replace the desktop AT. It lacks disk speed and the ability to accept AT-type add-in cards. Even so, few developers should be able to resist the idea of being able to do serious work whenever and wherever the inspiration strikes—as long as a power supply is available. Toshiba opted against battery power in the T3100, which operates at a switch-selectable 115 or 230 volts. If computing enroute is important, Product R&D, Inc. of San Luis Obispo, California, offers a 12-volt adapter for the T3100. This small unit replaces the power cord and allows the computer to plug into an automobile cigarette-lighter outlet or a six-pound battery pack. The battery can power the computer for one hour.

The T3100's 80286 processor can run at either 4 MHz or at 8 MHz. The lower speed is needed only by older, timing-dependent PC software, not packages designed for the AT. The slow mode is 4 MHz, rather than the normal 6 MHz, because, according to Toshiba, stepping the 8-MHz clock down by a power of 2 was easier than implementing a proportion of six-eighths. The speed is toggled from the keyboard with the Ctrl-Alt-PgDn combination for 4 MHz and Ctrl-Alt-PgUp for 8 MHz. Software using these same key combinations would cause a problem. The clock/calendar is powered by a small lithium battery located inside the case directly behind the keyboard.

The T3100 has a minimum memory size of 640KB, which can be increased to 2.6MB by a special internal card that provides AT-style extended memory. The card uses two banks of nine 1-megabit chips. Expanded memory can be acquired only via Toshiba's as-yet-unreleased expansion chassis.

Toshiba did not design the T3100 to support the 80287 numeric coprocessor. However, a third-party vendor, R Services of Anaheim, California, modifies the T3100 by moving the 80286 to a tiny daughterboard that also supports the 80287. The cost of this service is $549 plus shipping.

THE CURIOUS KEYBOARD

The T3100 keyboard is significantly different from the AT keyboard, as is apparent in photo 2. Although it generates the same codes that the AT keyboard does, it has fewer keys, which may present difficulties for some users.

Most of the incompatibilities lie in a few keys, particularly the missing numeric keypad. As is common in briefcase-size computers, a numeric keypad is embedded in the alphanumeric keyboard and is accessible via the NumLock key. A numeric keypad with connecting cord is available from Toshiba.

The layout of the keyboard is generally good, considering the space limitations. The size and separation between the keys is comfortable, but the keys provide little tactile feedback. They seem to "bottom out" almost immediately after the keystroke is accepted.

All of the special-purpose keys are colored dark gray, while the alphanumeric keys are light gray. The Esc key is situated in the upper lefthand corner, preceding the 10 function keys, which stretch horizontally across the top. NumLock, ScrollLock, PrtSc, and SysReq complete the top row.

The Alt key is in the lower lefthand corner, with the left Shift, Ctrl, and Tab above it in their normal positions. The CapsLock and \ (backslash) keys have been relocated from their normal homes on the AT keyboard. Toshiba placed them between the Alt key and

the Space Bar, apparently to allow for an enlarged Backspace key and some consolidation of space on the right. The tilde, Ins, and Del keys are immediately to the right of the Space Bar. Backspace, Enter, and the right Shift key are exactly where expected; and Home, PgUp, PgDn, and End extend vertically along the right side of the keyboard.

The four arrow keys are located on the lower right of the keyboard, arranged in the inverted-T fashion of the IBM enhanced keyboard. The advantage to this design is that it allows the user to rest his hand while moving the cursor around a spreadsheet or document without bumping keys underneath. Many portables use a diamond arrangement at the top of the keyboard instead.

Unlike the T1100 Plus, which provides the gray plus and minus keys at the keyboard level, the T3100 provides them through the BIOS. The equivalent key combinations that must be entered on the T3100 for gray plus and minus are Alt-Shift-; and Alt-Shift-p, respectively. The front of the semicolon and *p* keys are marked with + and – signs. With the NumLock key on, they act as duplicates of the white plus and minus keys. As a result, some programs may have difficulty if they read the gray plus and minus keys directly from the keyboard rather than through the BIOS. To help alleviate this, Toshiba provides Borland's SuperKey with the T3100, although the user may have to spend considerable time figuring out how to make all these elements work together.

SEEING ORANGE

The T3100's display flips up briefcase-style from its closed position against the keyboard to reveal its distinctive orange screen. The plasma display can arguably be called the most technically advanced screen on any microcomputer; it is undoubtedly the most exotic. Most battery-powered portables use a liquid crystal display (LCD), which does not generate its own illumination but depends upon reflected overhead light (and lots of it.) Back-lit LCDs appear to be another solution, but the characters that they produce do not appear as crisp as those of the plasma display.

A standard color monitor can be attached to the T3100 if desired. A 9-pin connector is included for this purpose on the rear panel (see photo 3).

While still too new to have demonstrated many weaknesses, the T3100's orange plasma display has several advantages. It is vivid, easy on the eyes, and bright enough to read in dim light, although the brightness level cannot be adjusted. The display is compatible with the IBM Color Graphics Adapter (CGA), and it offers 640-by-400 bit-mapped graphics and high-resolution text.

Toshiba's 640-by-400 graphics mode is virtually identical to the AT&T 6300's graphics modes. However, AT&T video drivers specify an argument of 40H with the interrupt 10H function to invoke the graphics mode, whereas Toshiba specifies an argument of 74H. (Toshiba provides information on its bulletin board on how to modify software drivers intended for the AT&T 6300 so that they will work for the T3100's 640-by-400 graphics mode.)

A few incompatibility problems are evident with the plasma display. Some unexpected combinations of video attributes register as black-on-black, rendering the characters invisible—for example, reverse/bright video. This is most likely to occur with programs that display multiple windows.

If the software application allows it, the best solution is to request black-and-white (not IBM monochrome) video output. If black and white is not an available option, color is the next best choice because the plasma display normally tries to mimic a CGA. In case tinkering with the software does not clear up the problem, Toshiba provides a program on the system diskette called CHAD, short for change display mode. It allows the user to select from four video attributes for text-based programs: normal, reverse, intensified normal, and intensified reverse. Because CHAD is a memory-resident, pop-up program, changes can be made from within software that is already running.

Once loaded, the CHAD menu can be called from within other programs by pressing the SysReq key. The user can then select from the four video attributes or enter CHAD parameters directly from the command line or an AUTOEXEC.BAT file. CHAD's major limitation is that it cannot be used with software that works in graphics mode.

Another drawback of the Toshiba plasma display is its inability to display underlined characters in text mode, thus limiting the ability of software to operate in what-you-see-is-what-you-get text mode. This will be especially noticeable to those accustomed to using an IBM monochrome or Compaq Portable display in text mode.

Several indicator lights are positioned just below the screen on the bar that supports it in its upright position. The power/speed light indicates that the computer is on, and its color indicates whether the processor is running at 4 MHz (red) or 8 MHz (green). Two disk-in-use lights are situated side by side; the left light is for the internal hard disk, and the right light can indicate either the built-in 3½-inch drive or an external 5¼-inch drive.

The CRT light is superfluous in that it indicates whether the user is viewing an RGB monitor or the built-in plasma display, a fairly obvious observation. CapsLock, NumLock, and ScrollLock lights are more noticeable in their locations below the T3100 screen than they are on the AT keyboard.

MEDIA INCOMPATIBILITY

Although the T3100 is AT compatible in most respects, it certainly is not media compatible. It contains only a 3½-inch diskette drive, which conforms to the emerging 720KB MS-DOS standard shared by the IBM PC Convertible and Data General One. Due to the use of the 3½-inch drive in the PC Convertible, more and more software is becoming available in this format. A partial list of the software available on the smaller diskettes is given in table 1.

TOSHIBA 3100 VITAL STATISTICS

T3100: $4,199
8-MHz 80286 microprocessor
640KB memory
Parallel printer/external drive interface
Serial interface
High-resolution plasma display
RGB interface
Realtime clock
720KB 3½-inch diskette drive
10MB hard-disk drive
Carrying case

Internal memory capacity
640KB; can be increased by 2MB of extended memory

Available slots
8-bit: 5

Options Available
External 5¼-inch, 360KB diskette drive: $499
2MB memory card: $1,699
Floppy Link diskette drive connection: $199
Separate numeric keypad: $99
Hayes-compatible internal modem: $399
Expansion chassis with cable: $999

PHOTO 1: *T3100 Packaging*

PHOTO 2: *Keyboard Comparison*

PHOTO 3: *Rear of the System Unit*

PHOTO 4: *External 5¼-inch Diskette Unit*

PHOTO 5: *Inside the System Unit*

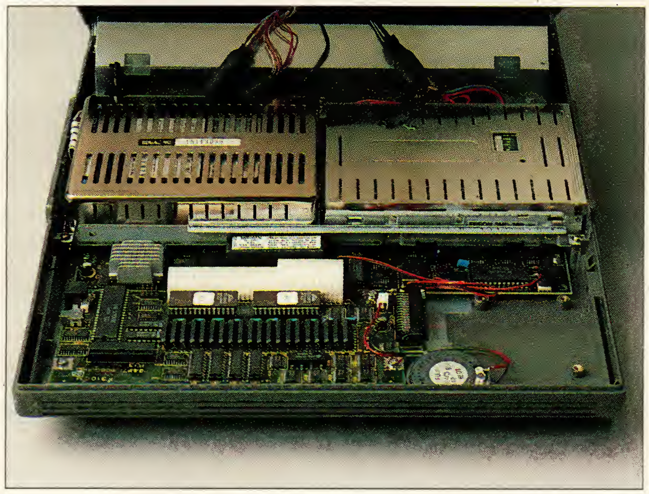

Photo 1: In this small 12-by-14-by-3-inch package Toshiba provides an AT compatible with a built-in plasma display, 10MB hard disk, and a 3½-inch, 720KB diskette drive.

Photo 2: Though functionally compatible with the AT keyboard, the T3100's keyboard looks quite different with fewer keys and a somewhat rearranged layout.

Photo 3: Connectors for the standard serial port, parallel port, and external RGB monitor driver are on the rear of the unit along with six system configuration switches.

Photo 4: Toshiba offers an external 5¼-inch, 360KB diskette drive that measures 6.5-by-12-by-2.5 inches and weighs six pounds. It plugs into a 25-pin parallel port on the rear panel.

Photo 5: The 80286 processor, 640KB memory, system ROM and space for 2MB of extended memory are all accommodated in the space available beneath the keyboard.

PHOTOGRAPHS • MARC DAVID COHEN

As durable, convenient, and reliable as the smaller drives and diskettes are, most users will still want the ability to read and write 5¼-inch diskettes that can be shared with a regular PC, especially if they want to run software from a copy-protected diskette.

Toshiba offers an optional external 5¼-inch diskette drive, measuring 6.5-inches wide by 12-inches deep by 2.5-inches high and weighing 6 pounds (see photo 4). It operates in standard 360KB MS-DOS format and, therefore, is not fully compatible with the AT's 1.2MB diskette drive. The drive also works with the T1100 Plus.

The external drive plugs into a 25-pin parallel port on the rear panel, using a cable furnished with the drive. Because both ends of the cable look the same, the user must be careful to plug the end marked SYSTEM into the computer and the end marked EXT.FDD into the drive; otherwise, the drive will not operate properly. It runs on 18-volt DC power provided by a detachable AC power adapter. The power switch is located on the lower rear of the left-hand side of the drive, somewhat concealed by an overhang in the case.

On the left side of the T3100 is a three-position switch marked A/B/PRT. If no external drive is attached, the switch should be set to PRT, leaving the port ready to drive a parallel printer or other device. The built-in 3½-inch drive is then automatically designated drive A:. With an external drive attached, the switch is used to specify its drive designation, and the internal diskette drive assumes the remaining designation.

Unfortunately, the external drive and a parallel printer cannot be attached at the same time. A user who wants to switch between a printer and the external drive must switch cables, change the A/B/PRT switch, and reboot the computer each time.

Toshiba also offers an internal 3½-inch diskette drive for use in a desktop PC. It must replace an existing 5¼-inch unit, which most users will not easily abandon. IBM's external 3½-inch drive for the PC, which allows diskettes from the PC Convertible to run on a desktop PC, also supports the T3100; 3½-inch diskettes can be swapped safely between the T3100, the Convertible, and an external 3½-inch drive.

Another solution exists for media compatibility if the T3100 user has regular access to a desktop PC or AT. The Toshiba Floppy Link, a half-card that mounts in an 8-bit expansion slot of the PC, XT, or AT, turns one of the computer's diskette drives into a peripheral of the T3100. The half-card connects via cable to the T3100's parallel/FDD port.

TABLE 1: *3½-inch Software*

Clout (Microrim)
Crosstalk (DCA/Crosstalk)
enable (The Software Group)
Lotus 1-2-3 (Lotus Development Corp.)
Ready! (Living Videotext, Inc.)
Reflex (Borland)
Remote (DCA/Crosstalk)
R:base 5000 (Microrim)
SideKick (Borland)
SuperCalc4 (Computer Associates International, Inc.)
SuperKey (Borland)
ThinkTank (Living Videotext, Inc.)
Turbo Database (Borland)
Turbo Graphix (Borland)
Turbo Pascal (Borland)
WordPerfect (WordPerfect Corp.)
WordStar 2000 (MicroPro)
All Microsoft products except Chart, Windows, and Flight Simulator
The following will be available soon:
dBASE III PLUS (Ashton-Tate)
Framework II (Ashton-Tate)
MultiMate (Ashton-Tate)
Statpro (Penton Software)

With its use in the IBM PC Convertible, the 3½-inch diskette format is gaining acceptance; many software companies now support it.

The Floppy Link splices into the cable path between the desktop's controller and drive, allowing the T3100 to read and write 1.2MB diskettes when attached to a 1.2MB drive, or 360KB diskettes when attached to a 360KB drive. Because of this technique it will not work on some nonstandard drives such as those on the Epson Equity I.

Enterprising users can always hard-wire the T3100 and a desktop PC via their serial ports and exchange data and programs using a communications program with a protocol such as XMODEM. This may be slower, especially to transfer several files, but the only cost is a null modem cable.

EXTERNAL CONNECTORS

Unlike some flat-screen MS-DOS portables, notably the IBM PC Convertible, the T3100 does not need any optional add-ons to attach a variety of peripherals. The rear panel (photo 3) contains three industry-standard ports and connectors: an AT-type, 9-pin serial connector (male), a 25-pin parallel connector (female), and a 9-pin RGB connector (female) for a color monitor. The parallel port is used either to connect a printer or the Toshiba external 5¼-inch disk drive. Devices can be connected to or disconnected from the T3100 at any time without danger to the computer. Many portable manufacturers specifically warn against this procedure.

Also on the rear of the computer is a metal plate that covers a nonstandard expansion slot, which may be occupied by an optional Hayes-compatible 300/1200-bps direct-connect modem. Alternatively, the slot can be used to attach the expected expansion unit, which will provide the T3100 with five 8-bit, PC-type expansion slots. It will not support 16-bit AT cards, however, and lacks mounting space or power for large hard disks and tape backup units.

A bank of six microswitches located below the power connector is used to determine some configuration options. Switch 1 selects the English or European character set. Switch 2 limits accessible memory to 512KB to satisfy applications that require the lesser amount. Switch 3 determines if the internal display controller or a display controller mounted in the external chassis is to be used. Switch 4 controls signal conventions for the parallel port. The documentation indicates that the setting should be down when the parallel port is used with a printer or external disk drive. The up position enables an input device. Switch 5 determines if the low and high plasma display intensities use single-dot/double-dot representation or the reverse. Whether the serial port or the internal modem is addressed as COM1 or COM2 is controlled by switch 6.

Software configuration and setting the clock are performed via the TEST program supplied on the DOS diskette, while keyboard options are invoked by key combinations called *soft switches.*

All of the external connectors and the microswitches are protected by the solid carrying handle when the computer is closed up. The handle folds down to support the rear of the unit when placed on a desk. Unfortunately, the 3½-inch diskette drive is not protected from dust unless the entire computer is zipped inside its nylon case.

PEERING INSIDE

Although Toshiba does not regard the T3100 as user serviceable, the unit can be opened if necessary—for example, to change the clock battery. Three Phillips-head screws in the back and five on the bottom of the unit hold the case in place. These screws mate with brass fittings countersunk into the plastic case,

so they will not easily strip out. After removing all screws, the top of the case can be raised by pressing in gently on the sides near the Esc and SysReq keys. It can be lifted about two inches and rotated to access the keyboard. Lifting the top any further may damage the cables to the plasma display.

Photo 5 shows the T3100 with the cover and keyboard removed. The 80286 can be seen at the upper left, covered by a heat sink. The lithium battery that maintains the system's CMOS configuration memory is to the right of the 80286. The connector for the optional external numeric keypad is just below and to the left of the 80286. The A/B/PRT switch is below that connector. The system ROM is to the right, with the 640KB of memory just below it. On the right-hand end of the circuit board is the connector for the optional 2MB memory expansion board, and below that is the system speaker.

The T3100's 3½-inch, 10MB hard disk, manufactured by JVC, is extremely slow. Furthermore, the heads have been programmed to park themselves after only five seconds of inactivity. Toshiba evidently decided that the possibility of the computer being moved at any moment, even while it is running, took precedence over the loss of a few seconds of disk access time.

The hard disk is always drive C:, and the system behaves just as an AT compatible should; if a diskette is found in drive A:, the system attempts to boot from it. If no diskette is in the drive, the system boots from the hard disk.

MS-DOS 2.11 was provided with the reviewed system; however, Toshiba plans to provide version 3.2 in the near future. Microsoft Advanced BASIC-86 version 1.11 is distributed on the T3100 hard disk along with DOS, but with no documentation or clue that it is there. Borland's SuperKey 1.16A is provided to help users overcome frustration with the keyboard, although, as noted earlier, it is not always sufficient. SideKick 1.56A, Borland's ubiquitous utility, is also included with the system.

TABLE 2: *Compatibility and Performance Tests*

	8-MHz AT, 30MB DISK [a]	TOSHIBA 3100, 10MB DISK
ATBIOS		
ROM BIOS date	11/15/85	08/18/86
ATPERF		
Average RAM instruction fetch (µs)		
BYTE	.250	.25 (99)[b]
WORD	.403	.41 (99)
Average RAM read time (µs)		
BYTE	.401	.42 (95)
WORD	.401	.42 (95)
Average RAM write time (µs)		
BYTE	.401	.39 (102)
WORD	.401	.39 (102)
Average ROM read time (µs)		
BYTE	.401	.42 (95)
WORD	.401	.42 (95)
Average CGA video write time (µs)		
BYTE	1.208	1.00 (120)
WORD	2.415	2.01 (120)
CPU clock rate (MHz)	8.0	8.0 (100)
Refresh overhead (%)	7.1	8.6
RAM read wait states	1	1
RAM write wait states	1	1
ROM read wait states	1	1
Video write wait states (CGA)	8	6
ATFLOAT		
Performance as percentage relative to AT	100	20
ATDISK		
Sectors/track	17	17
Heads	5	2
Cylinders	731	610
Total space (million bytes)	31.81	10.62
Track-track seek time (ms)	6.0	38.7
Average seek time (ms)	37.1	159.9
Effective transfer rate (KB/sec)	170.1	82.3
DOS file I/O (sec)	7.3	20.7
Interleave	3	3

[a] *The figures for the IBM AT are the average results from several machines, whereas the results from the Toshiba 3100 are taken only from the review sample model.*
[b] *Figures shown in parentheses represent the relative performance expressed as a percentage compared to* PC Tech Journal's *baseline machine, the 8-MHz, 30MB AT.*

While the T3100 provides processor and memory performance on a par with that of the AT, it provides less hard-disk capacity and far less hard-disk performance.

TESTS PROVE COMPATIBILITY

As with the Compaq Portable III and all of the other systems tested in this series on AT compatibles, the T3100 was evaluated using the two sets of standard tests first described in "Out from the Shadow of IBM," (Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52) and then revised in "Updating the Evaluation Suite," (Ted Forgeron, Paul Pierce, and Steven Armbrust, March 1987, p. 70).

First, commonly used hardware and software were installed to test AT compatibility. The hardware products worked without any problems in the T3100. They included a Microsoft serial mouse, an IBM Color Graphics Display, and an IBM ProPrinter. Add-in cards could not be tested because the optional expansion unit was not yet available.

DCA/Crosstalk Communications' Crosstalk XVI, Hayes' Smartcomm II, and Microsoft Word were used with the T3100, all with good results.

A few difficulties were encountered with Crosstalk, caused by its assumption that it should use COM1. The Crosstalk auto files were edited to use COM2 instead of flipping the microswitch on the back of the T3100. Smartcomm II worked perfectly with the modem at both 300 and 1200 bps.

Microsoft Word 3.0 pointed out the flaw mentioned earlier in the implementation of the gray plus and minus keys. Word uses these keys to expand and collapse outlines and, in conjunc-

tion with the Shift keys, to expand and collapse text blocks under outline headers. This feature would not work on the T3100. Version 3.1 has implemented a fix that adds the combinations Ctrl-2 and Ctrl-6 to expand and collapse the outline (shifted for text).

Word 3.1 also supports the T3100 enhanced graphics mode, taking advantage of the 640-by-400 resolution of the plasma display. Unfortunately, this enhanced image cannot be redirected through the RGB port without causing a standard color monitor to lose its synchronization. Some adaptable-sync monitors can display the redirected image. This feature is not documented, perhaps because the image is clipped at the top and right of the screen.

The terminate-and-stay-resident (TSR) programs SideKick and SuperKey ran without problems on the T3100. As with the Compaq Portable III, the combination of graphics and TSR programs did present some problems. SideKick worked well when configured to be used over graphics and invoked with the plasma display in CGA mode; however, when the program was invoked with the display in the 640-by-400 mode, the plasma display was unreadable once control was returned to the executing program.

The IBM AT Advanced Diagnostics were used to perform a general system check. Because the T3100's 10MB hard disk is a type not defined for the AT, SETUP had to be run to delete it from the system configuration before the diagnostics could be used. Not surprisingly, the T3100 failed the Advanced Diagnostics keyboard test.

The T3100 also was tested using the *PC Tech Journal* Evaluation Suite, consisting of five programs that test compatibility and performance. Table 2 lists the results of these tests.

ATBIOS indicated the standard use of the ROM BIOS data area. It displayed a copyright date of 8/18/86.

The T3100 performs instruction fetch and RAM and ROM access at the same speed as an 8-MHz AT, according to the results of ATPERF. Video write performance using the T3100's internal display controller in CGA mode is actually somewhat faster than that obtained using a CGA in the AT.

The ATKEY test verified the keyboard's functional compatibility.

ATFLOAT indicated that the T3100 performs a typical floating-point application one-fifth as fast as the standard 8-MHz AT. The test was performed without an 80287. A T3100 modified by R Systems to use an 80287 should actually perform this test slightly faster than an AT, because R Systems indicates that the 80287 installed runs at 8 MHz as opposed to 5.33 MHz on the AT.

The T3100's hard disk is slow, as shown by ATDISK's measurement of an average access time of more than 150 milliseconds and an effective transfer rate less than half that of the AT.

TRAVELING MANUAL

Documentation is a strong point of the T3100. The single-volume *User's Manual* contains a comprehensive table of contents; the chapter-specific information is restated on a color cardboard foldout at the beginning of each chapter. The foldouts also provide the photos and drawings referenced in the chapter. The experienced user can scan the "Quick Start" chapter and use the indexing features in about ten minutes. The Toshiba documentation is designed for easy traveling with the computer. The soft cover and spiral binding encourage the user to slip a manual into the carrying case for use when needed.

With its expansion chassis the T3100 can become an integral part of a local area network without losing its portability.

The major flaw of the documentation is in its lack of technical details. The inadequate description of the numeric keypad and the CHAD program are examples. A DOS manual is available as well, identical to the manual supplied with the T1100 Plus. A *Technical Reference* manual is offered only through the customer assistance group.

Toshiba has implemented three different support programs for the T3100. A toll-free number puts the perplexed user in touch with a technician. Toshiba hopes to resolve most cases of user error and documentation oversights this way. If the T3100 has been physically damaged or stops working, the Exceptional Care Warranty Service supplies a replacement unit within a few days. The customer ships the defective machine to Toshiba and receives a loaner by overnight air. The user is responsible for preserving the contents of the hard disk if the machine must be repaired. This repair program expires after the one-year warranty, but can be renewed for an additional two years for extra cost. Toshiba also maintains a bulletin board system for its products.

EASY TO TAKE

The T3100 is a lot of computer in a very small package. For a portable computer, it provides a fast CPU and memory and adequate disk capacity and performance. Its weaknesses are primarily in the area of compatibility. The use of a single 3½-inch diskette drive makes access to software inconvenient because of the current predominance of 5¼-inch media. Toshiba has tried to ameliorate the situation by offering options such as the external 5¼-inch diskette drive and Floppy Link.

The plasma display is crisp and readable, but could be brighter, particularly for use in brightly lit environments. Also, its high resolution can be exploited only by software specifically designed or modifed for use on the T3100. Finally, and perhaps most obviously, although the keyboard features full-size keys, the layout is sufficiently different from the AT to confuse a user who must adapt to both keyboards.

The beauty of this machine is in its performance to portability ratio, however. Though designed for portability, the T3100 is powerful enough to be useful in the office as well. When the expansion chassis becomes available, the T3100 can become an integral part of a local area network (LAN) without losing any of its portability. It can be connected to the expansion unit in the office and disconnected for travel.

The T3100 is convenient for security-conscious users who want to take their computers home with them each night or lock them up in their desk drawers. It is ideal for traveling consultants, accountants, salespeople, and others who spend a lot of time on the road but who do not want to be without a powerful computer.

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Irvine, CA 92718
714/380-3000
Toshiba T3100

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Ashley Grayson is the founder of ADG in San Pedro, California, a company specializing in high-technology sales tools and product documentation. John Vornholt is a project manager at ADG. Grayson and Vornholt have written Computers to Go: A Guide to Briefcase Portables *(Simon and Schuster, 1985).*

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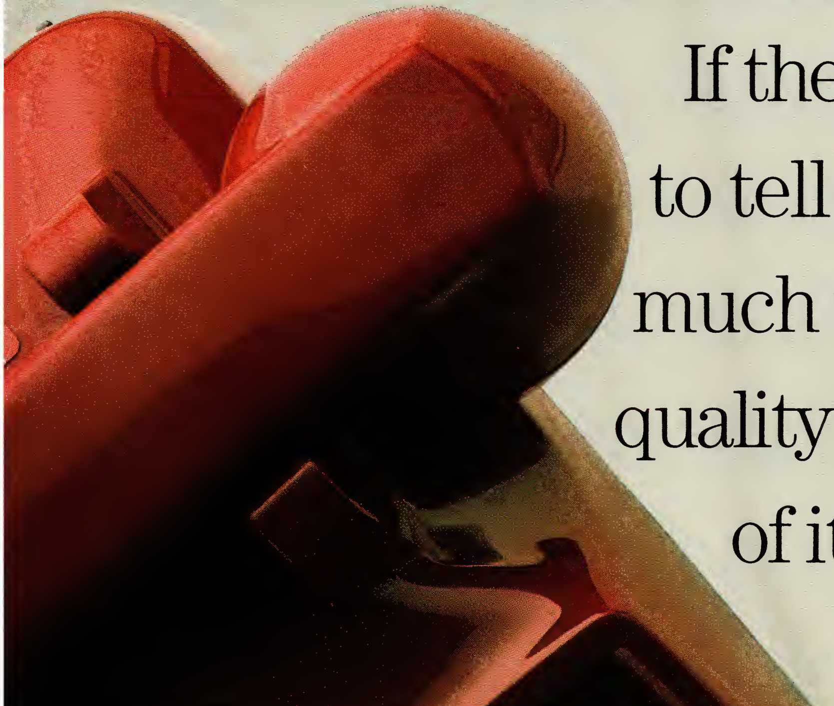

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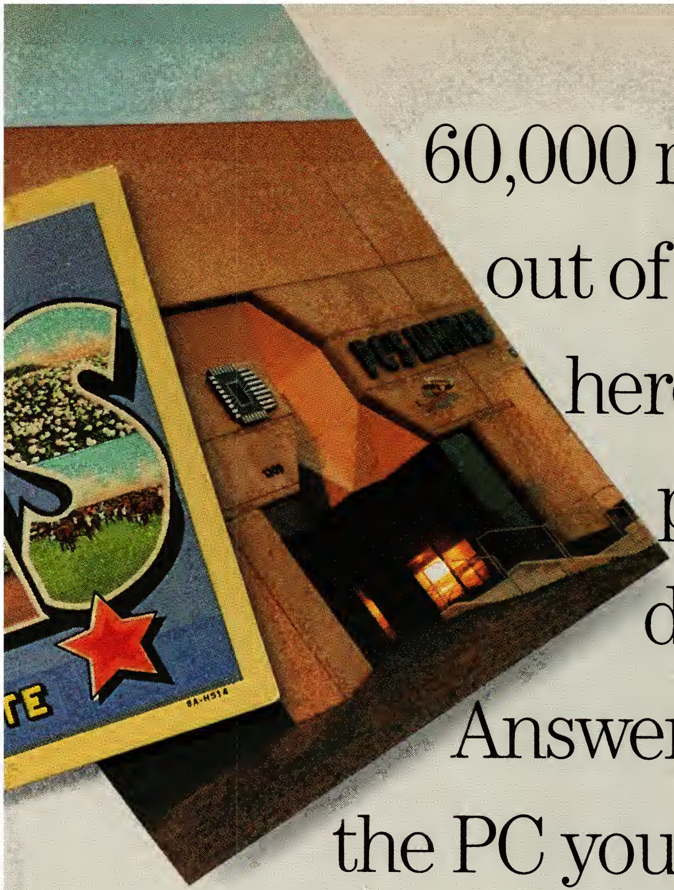

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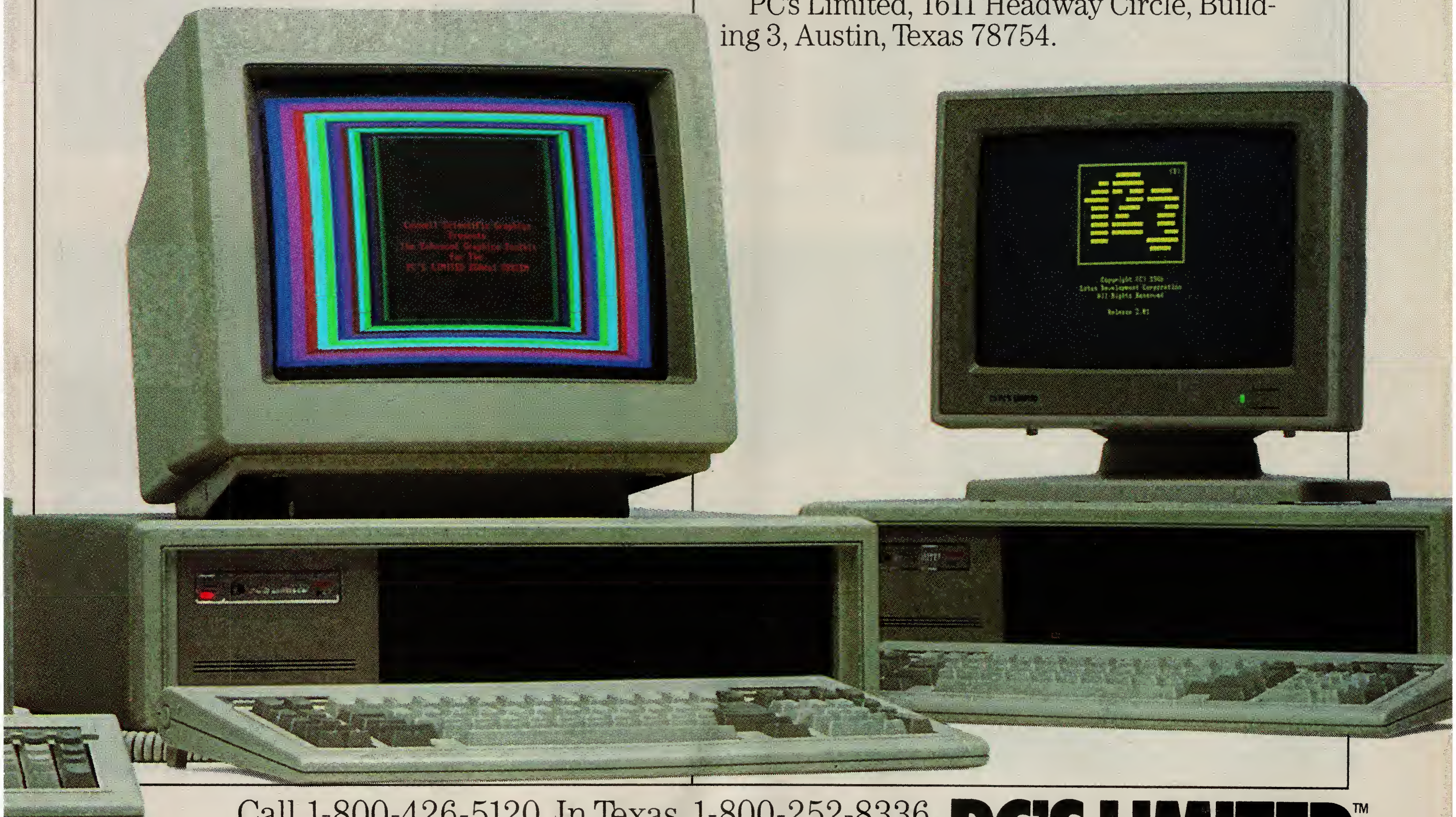

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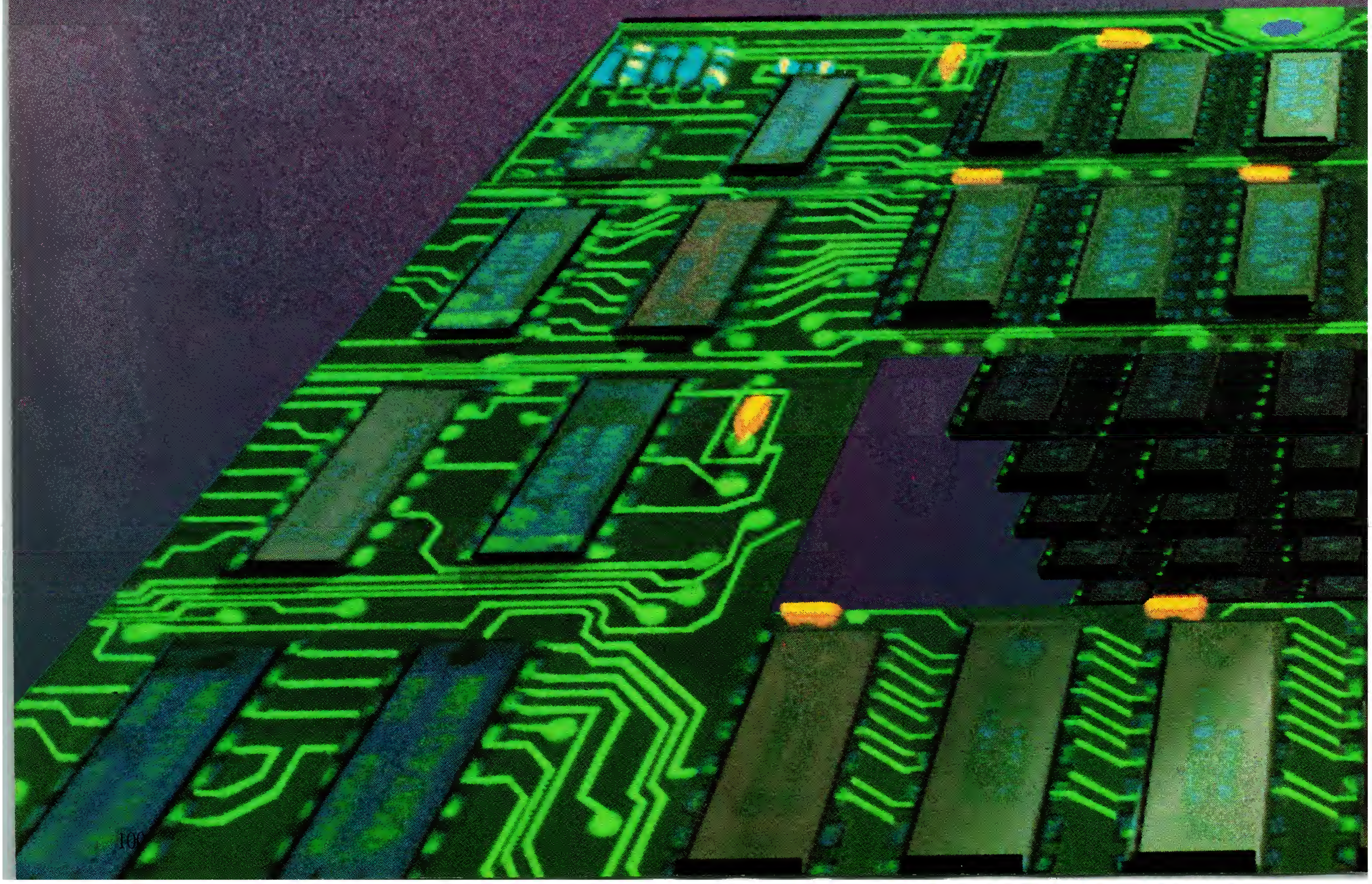
Reaching into Expanded Memory

Applications that access the full bounds of expanded memory must respect the software interface and the underlying hardware.

JOHN A. LEFOR and KAREN LUND



If every user were to describe the ultimate personal computer, the one requirement common to all would probably be unlimited memory. In today's computing environment, with larger applications, memory-resident programs, integrated software, and multitasking systems (such as Quarterdeck's DESQview and Microsoft Windows), available memory seems inadequate.

One of the more commercially successful ways to increase memory in the PC is to use expanded memory as defined by the Lotus/Intel/Microsoft Expanded Memory Specification (LIM EMS) and its superset, the AST/Quadram/Ashton-Tate Enhanced Expanded Memory Specification (AQA EEMS). Although early versions of these specifications were somewhat hardware-dependent, this situation has been remedied in more recent versions. Instead of defining hardware, LIM EMS and AQA EEMS now define the software interface between the application that will use expanded memory and the Expanded Memory Manager (EMM)—an installable device driver that operates on some unspecified expanded-memory hardware.

This independence from hardware has encouraged the development of expanded-memory products separate from expanded-memory hardware. Known as EMS emulators, these products provide the interface LIM EMS requires but use PC/AT extended memory or disk space to replace the expanded-memory board.

Regardless of the medium that is used to deliver the expanded memory, the applications developer must understand both the software interface and underlying hardware principles in order to use it. (For a detailed discussion on LIM EMS and AQA EEMS hardware, see "Expandable Memory," Ted Mirecki, February 1986, p. 66.)

This article examines the use of LIM EMS and AQA EEMS from an applications development standpoint. Although it addresses some hardware issues, the article primarily explores the software interface. Sample programs are included to demonstrate software interaction with EMS hardware, and the following LIM EMS definitions are used:

Conventional memory. This is the linear address space under DOS control. In the IBM PC and most compatibles, conventional memory is limited to 640KB by the hardware design rather than by any limitation inherent in the operating system. In the 1MB (1,024KB) addressable by the 8088 processor, the remaining 384KB are reserved for the BIOS, hardware adapters, and several other system requirements.

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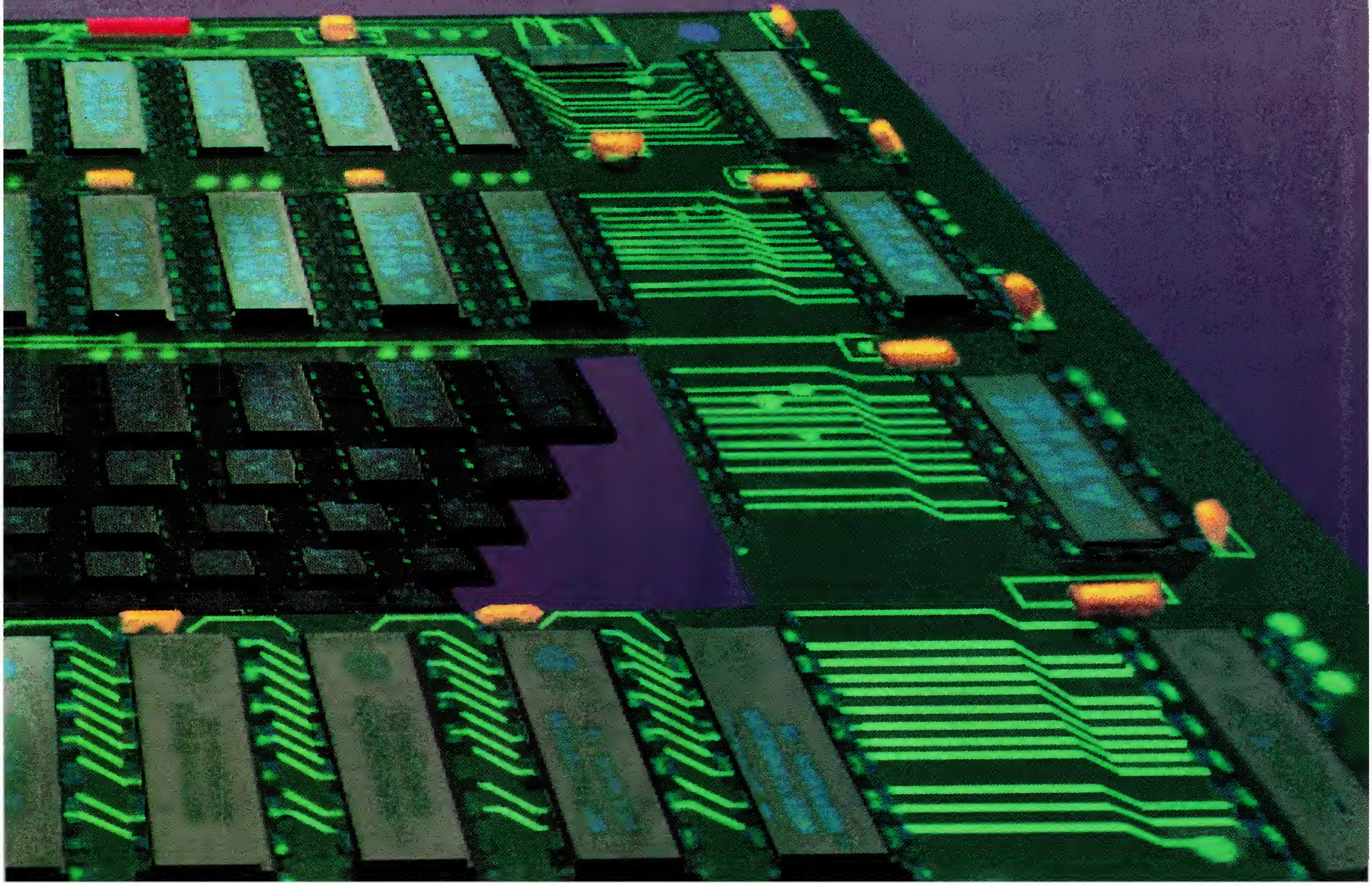

Expanded memory. This is the memory addressable through LIM EMS or AQA EEMS. While both specifications permit a maximum 8MB of expanded memory, this address space is nonlinear; that is, only a small portion of it is visible to the current application at any one time (the amount differs significantly between LIM EMS and AQA EEMS).

Extended memory. This linearly addressable memory above 1MB is possible only in 80286 machines. Although an 80286 can have up to 15MB of extended memory, it is addressable only in protected mode. Because current DOS versions do not support the protected mode, use of extended memory is limited to those few applications written specifically to employ extended memory without the operating system's intervention—such as RAM disks, print spoolers, and EMS emulators.

COMPARING MEMORIES

Expanded memory is divided into *pages* of 16KB. Thus, a typical expanded-memory board containing 2MB (2,048KB) of RAM provides 128 pages, and the maximum complement of 8MB provides 512 pages. Although an application program may use any number of these pages, only a limited number is accessible to the program at any one time—four in LIM EMS, possibly more in AQA EEMS. A page becomes accessible when it is mapped into a *page frame*, or *window*, of address space. Requests from programs for the allocation of pages and the mapping of pages to page frames are handled by the EMM.

In LIM EMS, the four page frames form a contiguous block of 64KB above conventional memory. During installation of an EMS board, these page frames are placed in a free area not already populated with RAM or ROM. Each page frame has a *page register* that determines what page is currently mapped to that frame. When the EMM maps a new page to a particular frame, it merely writes a new value to the associated page register, which is implemented as an I/O port—no data are moved. The set of active pages defined by the contents of all four page registers is called the *context*.

AQA EEMS differs from the LIM EMS in three significant ways. First, EEMS is not limited to four page frames, but is restricted only by the number of available 16KB blocks in the upper 384KB of memory space. Only four of these page frames must be contiguous for compatibility with the LIM EMS. Second, AQA EEMS provides two contexts—one active and one dormant; LIM EMS provides only one. The Enhanced EMM (EEMM) can switch between these two contexts with less effort than is involved in saving and restoring the contents of page registers. Third, AQA EEMS allows additional page frames within conventional DOS memory. Any 16KB block not populated by conventional RAM or ROM can potentially be filled by a page of expanded memory. This is different from backfilling memory, which can be done by both LIM EMS and AQA EEMS. Memory used for backfilling is removed from the expanded-memory page pool and permanently assigned to an address in the DOS memory space.

Although in theory AQA EEMS allows up to 64 physical-page frames, in practice this is not possible because pages can be mapped only into addresses that are free of standard RAM and ROM—64 page frames would require that the entire megabyte of address space be vacant. Most systems need a minimum amount of RAM on the motherboard (64KB for a PC/XT and 256KB for an AT) in order to boot. The high 384KB of memory is also populated with video buffer memory on display adapters and ROM code for BIOS, BASIC, and hardware such as hard disks, EGA (enhanced graphics adapter) boards, and local area networks.

In AQA EEMS, any 16KB block not populated by conventional RAM or ROM can potentially be filled by a page of expanded memory.

AQA EEMS has been designed so that any application written for LIM EMS also can run on the enhanced hardware and drivers. However, the converse does not hold: applications written specifically for AQA EEMS do not run on LIM EMS systems.

Because AQA EEMS provides switching between page contexts, two or more processes may operate in the expanded memory concurrently. This can occur even in a single-tasking environment such as DOS, where a terminate-and-stay-resident (TSR) program or device driver may "own" pages and access them while another program is using the page frames. This context switching becomes even more important when expanded memory is used for task-switching environments.

Early versions of LIM EMS provided only primitive support for task switching. In the original specification, the number of contexts that could be saved and restored was determined by the EMM and not by the application. As multitasking operating environments became popular, LIM EMS was expanded to include functions that allow the application to control the number of contexts that can be saved and restored, thus allowing context switching to an arbitrary depth.

The enhancements that are provided by AQA EEMS appear to have been designed with multitasking in mind. Rapid context switching is supported explicitly by the ability to move between two sets of context registers with only one call to the EMM. As demonstrated by DESQview, memory mapping below the 640KB boundary allows the swapping of programs with no memory-to-memory movement.

Several EMS emulator programs have been released that use expanded memory. Because expanded-memory specifications are based on a software interface and do not have explicit hardware requirements to provide the expanded memory, these emulators can provide EMS functions using either extended memory or disk files.

Emulators differ in how they provide this expanded memory. Those designed for 8088/80286-based systems rely on memory swapping rather than bank switching: the EMM physically transfers data from the medium emulating expanded memory (for example, extended memory or a disk file) to a page frame in conventional memory. When another page is transferred into conventional memory or the context is saved, the EMM must move the data from the window back to the medium. The window itself typically resides somewhere within the 640KB because no hardware exists to provide physical memory between 640KB and 1MB.

EMS Emulators designed for 80386 systems use the internal paging mechanism of the 80386's virtual 8086 mode to provide expanded memory and are functionally equivalent to EMS/EEMS boards. (For a discussion of the 80386 processor and the virtual 8086 mode, see "Upward to the 80386," Caldwell Crosswy and Mike Perez, February 1987, p. 51.) To date no emulators compatible with the AQA EEMS have been released, probably because the applications that use its enhancements would not perform adequately under emulation.

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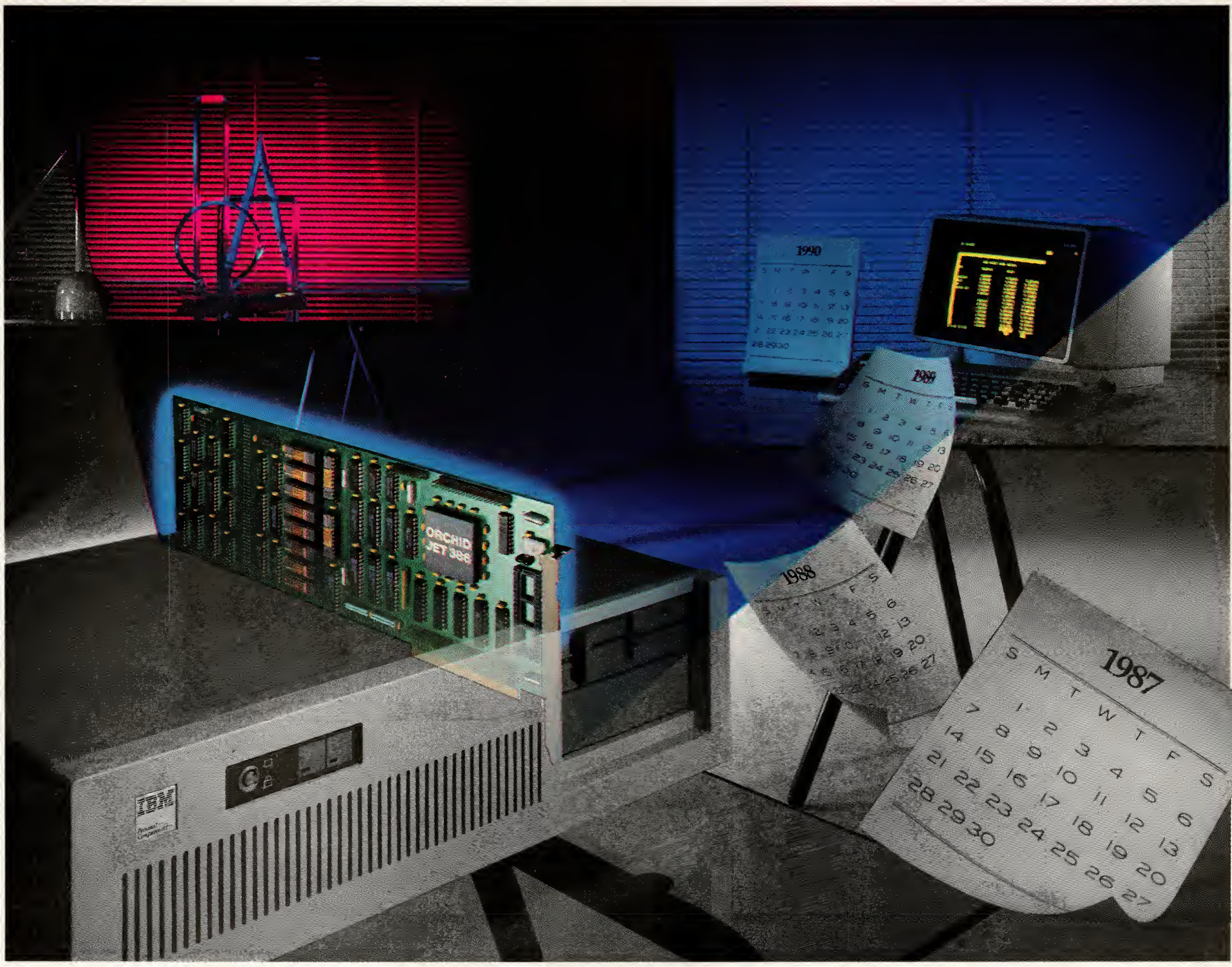

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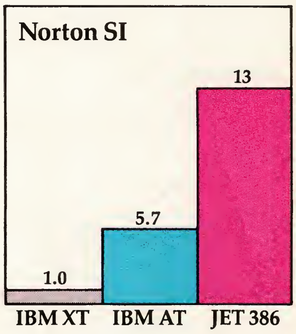

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EXPANDED MEMORY MANAGER

The key to using expanded memory is an understanding of the services defined by the specification and implemented by the aforementioned Expanded Memory Manager (EMM). The EMM is to expanded memory what BIOS is to the PC: it provides applications with hardware-independent access to expanded memory by performing the memory-management functions defined by the specification.

The EMM is loaded during DOS initialization by an entry in CONFIG.SYS. When the EMM is loaded into low memory, DOS transfers control to the EMM's start-up routine, which generally displays a message indicating the presence of expanded memory, tests the expanded memory for proper operation, and installs an interrupt handler for interrupt 67H. This interrupt is the primary mechanism for communications between the application program and EMM. Once the EMM has been installed, it can be used by other device drivers installed subsequently and by resident and transient applications.

Before using expanded memory, an application must first determine whether expanded memory is available in the system using one of two methods: *open handle* or *get interrupt vector*. The open-handle method uses DOS calls to establish the existence of a device driver. Although somewhat complicated, it is the preferred technique for an application program. However, the open-handle method cannot be used by device drivers because the DOS calls it uses are not present when the drivers are initialized. This method also is not recommended if the application interrupts DOS during DOS operations: because DOS is not reentrant, such action can cause unpredictable results.

The open-handle method is based on the installable device driver being called EMMXXXX0. Standard DOS interrupt 21H calls can be used to determine if this file exists in the system and if it is a device driver. To determine whether the file EMMXXXXO exists, DS:DX is set to point to an ASCIIZ string containing EMMXXXX0 and a DOS OPEN (function code 3DH of interrupt 21H) in read-only mode is issued. If the DOS OPEN terminates normally (that is, if the carry status flag is not set), then either the EMM is present or a disk file exists on the default drive with the name EMMXXXX0.

If the DOS call fails, either no EMM exists in the system or no more handles are available for opening files. The DOS error code can be used to determine which condition exists. To help ensure the availability of a handle, this test should be performed before any other files are opened. Otherwise, the get-interrupt-vector method may be used.

If the DOS OPEN is successful, an IOCTL (function code 44H) with a request to get device information (AL contains 0) must be used to determine whether the EMM or a file is present. If the carry flag is set after the call, the EMM is not present. If it is not set, the program should test bit 7 of DX, which specifies either a file or a device handle. If bit 7 is 0, the EMM is not present; if bit 7 is 1, the EMM is present.

As a final test, an IOCTL (function code 44H) must be issued with a get-output-status request (AL equals 7). The EMM is available if register AL returns 0FFH. The EMMXXXX0 file then should be closed (function code 3EH) to free the handle for future use.

The get-interrupt-vector method is based on the knowledge that interrupt 67H is the EMM call, and, therefore, the segment portion of the interrupt vector points to the segment containing the EMM. The interrupt vector is obtained by loading 67H into the AL register, then issuing DOS function call 35H (get vector). Upon return, ES:BX contain the far address of the interrupt handler. If the EMM has been loaded, its device header is located at ES:0 and its name is at ES:0AH. If the name is EMMXXXX0, the EMM is present.

The EMM is to expanded memory what BIOS is to the PC: it performs memory-management functions defined by the specification.

However, interrupt 67H is not reserved for the EMM's exclusive use: any software can use it, and in fact, several commercial products do, although they do not use LIM EMS function codes. LIM EMS specifically recommends against running any software that uses this vector when the EMM is present, but in practice it is impossible to ensure compliance. If another program takes control at interrupt 67H, the get-interrupt-vector method may not find EMMXXXX0 at offset 0AH into the segment of interrupt 67H even though the EMM is present elsewhere.

In addition, if the EMM is not loaded but the string EMMXXXX0 is present at the correct offset from interrupt 67H, then the application might conclude that expanded memory is present when, in fact, it is not.

CALLING ON MEMORY

Once an application has determined the presence of expanded memory, all communications between the application and expanded memory are conducted using interrupt 67H. Virtually all access to expanded memory is performed by placing a function code in the AH register, setting up other registers as required, and issuing an interrupt 67H. A return code is always placed in AH and should be examined upon return from the interrupt. A general template for EMM calls follows:

```
MOVAH, function_code  ; load function
                        code
INT 67H               ; call EMM
OR AH, AH             ; test return code
JNZ error             ; if non-zero an
                        error
                      ; has occurred
; code to process normal return from
; EMM follows
```

The EMM calls defined by the base LIM EMS are listed in table 1 and discussed below in their functional groups. According to LIM EMS convention, functions are referred to by number rather than by function code.

Initialization. The first call after establishing the presence of the EMM is function 1 (get status) which returns the EMM's status in the AH register. A status of any value other than zero indicates a problem with the EMM and the expanded memory should not be used.

To verify that the EMM is compatible with the application, its version may be ascertained by using function 7 (get version). The EMM version is returned in the AL register in binary-coded-decimal (BCD) format: for version 3.2 of EMS this value should be 32H.

To ensure that sufficient memory is available to run the application in expanded memory, function 3 (get page count) may be used. This call returns the number of available expanded-memory pages in the BX register and the total number of expanded-memory pages in the system in the DX register. It is used not only to determine if enough pages are available to accommodate the particular application, but also to ensure a fair use of the available pages among all applications. For example, if an application can use all available expanded memory, but requires

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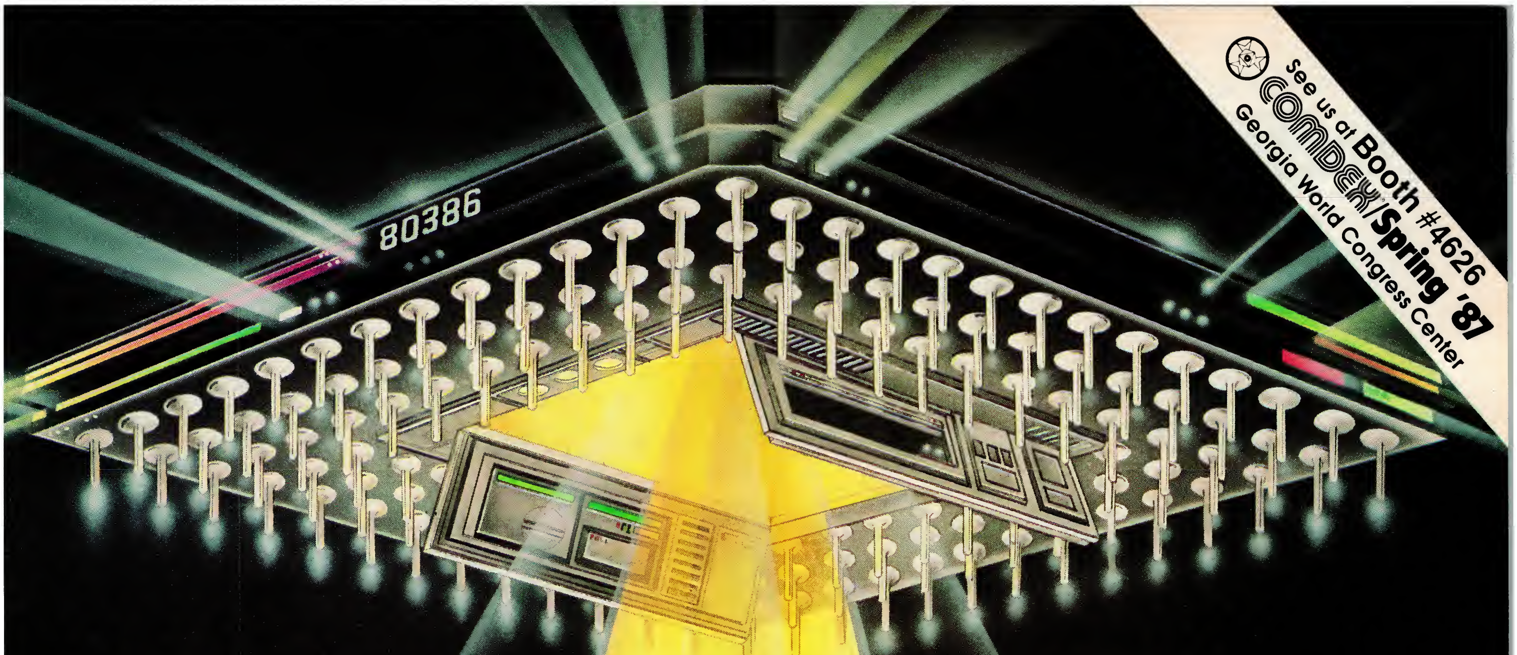

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TABLE 1: *EMS Functions and Calling Sequences*

FUNCTION NAME AND NUMBER	FUNCTION CODE IN AH	CALLING ARGUMENTS	RETURNED VALUES
INITIALIZATION			
1. Get status	40H	None	AH: status
2. Get page frame address	41H	None	AH: status register BX: page frame segment
3. Get page count	42H	None	AH: status BX: pages free DX: total pages
7. Get EMM version	46H	None	AH: status AL: BCD version number
ALLOCATION/DEALLOCATION			
4. Allocate pages	43H	BX: number of pages	AH: status DX: handle
5. Map memory	44H	AL: window number BX: page number DX: handle	AH: status
6. Deallocate pages	45H	DX: handle	AH: status
MULTITASKING SUPPORT			
8. Save page map	47H	DX: handle	AH: status
9. Restore page map	48H	DX: handle	AH: status
15. Get/set/swap page map	4EH	AL: 0 (get map) ES:DI → memory array	AH: status ES:DI → saved page map
		AL: 1 (set map) DS:SI → saved page map	AH: status
		AL: 2 (swap) ES:DI → memory array DS:SI → next page map	AH: status ES:DI → previous page map
		AL: 3 (get size)	AH: status AL: size of page map, bytes
MANAGEMENT			
12. Get handle count	4BH	None	AH: status BX: number of handles
13. Get page count for a handle	4CH	DX: handle	AH: status BX: number of pages
14. Get page counts for all handles	4DH	ES:DI → memory array	AH: status BX: number of handles ES:DI → filled-in array

The thirteen nonreserved functions supported by the EMS expanded memory manager (EMM) are arranged above by category. The function code is the value that is placed in the AH register when the EMM is invoked by executing interrupt 67H.

only a small number of pages at any one time, the ratio of available to total pages can be used to weight the number of pages to be allocated.

The last function performed during initialization determines the location of the page frames in memory: function 2 (get page frame address) returns the segment portion of the address of the page frame in BX. For LIM EMS applications and the first four page frames of AQA EEMS, BX:0000 is the address of physical page 0; BX:4000 is the address of physical page 1; BX:8000 is the address of physical page 2; and BX:C000 is the address of physical page 3.

Allocation/deallocation. Once the application has determined that sufficient expanded memory is available, it may issue function 4 (allocate pages) with the number of pages requested in BX. The EMM returns a unique handle, or identification number, for this set of pages in DX, and the program then refers to any page in the set by its handle and a *logical page number* from zero to *n*, where *n* is one less than the number placed in BX when the call was issued.

All of the memory needed for a program's execution need not be allocated at once. Although the number of pages identified by a handle cannot be changed, a program can obtain more memory by issuing additional calls to function 4. Each request returns a distinct handle number. Although memory usually should be left unallocated for as long as possible to ensure its fairest availability, this approach has two drawbacks: insufficient memory may remain when a subsequent request is issued and keeping track of multiple handles adds some overhead to the program.

Before an allocated page of expanded memory can be used by an application program, it must be mapped into a page frame using function 5 (map memory). To use this call, the address of the logical page to be mapped must be placed in the BX register, its handle in the DX register, and the number of its physical-page frame (0 to 3 for LIM EMS, 0 to some higher number for AQA EEMS) must be placed in the AL register. If no errors are returned after making the call, the application can address the logical page by accessing the appropriate page frame at the segment address determined by the call to function 2 (get page frame address).

The majority of calls to the EMM typically are made to function 5 because this function allows the application program to make selective use of as much as 8MB of expanded memory while using as little as 64KB of address space.

Function 6 (deallocate pages) returns the memory associated with a particular handle to the pool of available pages for use by other applications.

Multitasking support. Programs that are executed from within other applications (such as device drivers and TSRs) and programs that control task-switching of multiple applications, must follow special procedures when using expanded memory. The interrupting program must save the context (that is, the state of page registers) of the interrupting program before mapping new pages into the windows.

The state of the expanded memory may be saved and restored using two different sets of functions. In the early versions of the EMS, only functions 8 and 9 (save/restore page map) could be used to switch contexts. Resident programs, multitasking managers, and other interrupting programs still use these functions to save or restore the state of the currently executing application (the program being interrupted) before modifying the state of expanded memory. The EMM handle used by the interrupting program is passed into the DX register. (The handle of the interrupted program is not known to the interrupter.) The EMM then saves the page registers to an area reserved for this purpose or restores the registers from this area. The ability of the EMM to save and restore a page map is limited by the amount of memory available to the EMM for saving page maps. In addition, only one set of page-address registers can be saved for any given handle at any one time.

Function 15 (get/set page map) provides a more flexible mechanism for saving and restoring the state of existing memory. It is a single function with four separate subfunctions that, like functions 8 and 9, allow resident programs and multitasking monitors to use expanded memory. Unlike function 8, which saves only the state of the page registers when last used, function 15 saves a page map—a table that relates logical page numbers to physical page numbers for all of the active EMM handles. Its primary advantage is that it allows the application to control the context save area and, therefore, does not limit the number of tasks for which contexts can be saved and restored. Calling this function with AL set to 3 returns the amount of memory needed to save the page-map array.

With AL set to 0 and ES:DI pointing to a memory location, function 15 saves the state of expanded memory starting at the location indicated by ES:DI and using as much memory as the AL 3 call determines is necessary. With AL set to 1 and DS:SI pointing to a memory location at which a get function has previously saved an EMS state, this function restores or sets expanded memory to that previous state. When AL is set to 2, with ES:DI pointing to the address to receive the state and DS:SI pointing to the new state, this function performs a context swap; that is, it obtains the current status and restores a previous status if no errors occur.

Management functions. The final set of EMM functions available in both LIM EMS and AQA EEMS tests the status and use of expanded memory, and is used primarily for supervisory programs. Function 12 (get EMM handle count) determines the total number of handles in use by all users of expanded memory. If no errors are reported after invoking this function, the total number of active handles is returned in the BX register. Function 13 (get EMM handle pages) reports the number of pages allocated to a particular handle. The handle is placed in the DX register and the number of pages allocated to that handle is returned in the BX register.

The majority of calls to the EMM are made to function 5 (map memory), which arranges the efficient use of expanded memory.

Finally, function 14 (get all EMM handle pages) returns an array of all active handles and the number of pages allocated to each. ES:DI points to the array, which can never be more than 1KB in length. Each entry in the array contains two words: the first identifies the active handle, the second indicates the number of pages allocated to that handle. The function also returns in the BX register the number of active handles.

In version 3.2 of EMS and EEMS, two functions are reserved, but still supported for compatibility with earlier versions. These functions are hardware related and do not directly involve new applications. Function 10 (get port addresses) returns the I/O port addresses for all existing expanded-memory boards. Function 11 (get translation array) returns an array that indicates the physical-page number and board number of each logical page allocated to a particular handle. An application program could use these two functions to perform page mapping without involving the EMM, but this would be unacceptable in a multitasking environment.

ENHANCED CALLS

Since AQA EEMS is a proper superset of LIM EMS, all EMS functions are also valid in the EEMS. The only difference is in function 5 (map memory): in EEMS the physical-page frame number is not limited to zero through three as it is in EMS. The other EEMS functions, listed in table 2 and described below, support additional page frames, multiple contexts, and page frames in DOS memory. (Table 3 lists the error codes that may be returned in register AH by both EMS and EEMS functions.)

Function 33 (get standard physical window array) performs two functions. First, it returns in register AL the number of windows (page frames) outside of DOS memory. This value is one more than the maximum physical-window number that can used in register AL when invoking function 5. These windows typically are above the 640KB of conventional memory, but if DOS memory has been configured to some lower value (that is, if the EEMS memory board does not backfill DOS memory to the maximum), the windows may start lower. Second, it fills an array at ES:DI with the addresses of each of these windows. In this respect, function 33 is an extension of EMS function 2. The four EMS page frames are contiguous, so the single address of page zero will be sufficient to locate all of them. However, because EEMS windows are not contiguous, except for the first four, the address of each one must be given separately.

The length of the window-address array, given by the number in AL, can never be more than 64 bytes. Each entry consists of the most significant six bits of the segment address of a window. For example, a window at segment D000H has an entry of 34H; and a window at D400H has an entry of 35H. It is unfortunate that the authors of EEMS did not choose eight bits to represent the page address, because then each entry would consist of the high-order byte of the segment address (D0H and D4H in the example above.)

TABLE 2: *Additional EEMS Functions and Calling Sequences*

FUNCTION NAME AND NUMBER	FUNCTION CODE IN AH	CALLING ARGUMENTS	RETURNED VALUES
33. Get physical window array	60H	ES:DI → memory array	AH: status AL: number of entries ES:DI → filled-in array
41. Get system physical window array	68H	ES:DI → memory array	AH: status AL: number of entries ES:DI → filled-in array
42. Map page into window	69H	AL: window number BX: page number DX: handle	AH: status
43. System map control Get system map	6AH	AL: 0 CH: first window CL: window count ES:DI → array	AH: status ES:DI → saved page map
Set system map		AL: 1 CH: first window CL: window count DS:SI → saved page map	AH: status
Swap system map		AL: 2 CH: first window CL: window count ES:DI → array DS:SI → next page map	AH: status ES:DI → previous page map
Get map size		AL: 3 CH: first window CL: window count	AH: status AL: size of array, bytes
Set standard mapping		AL: 4	AH: status
Set alternate mapping		AL: 5	AH: status
Deallocate initial system pages		AL: 6 CH: first window CL: window count	AH: status

An Enhanced EMS (EEMS) memory manager supports these four functions in addition to the standard EMS functions in table 1.

This would not only make address calculations easier, but also would make the array much more readable for debugging. Function 41 (get system physical window array) performs a parallel function for *all* windows, both inside and outside the DOS memory space.

After using either function 33 or 41, the segment address of page frame *n* can be determined by loading a byte from ES:DI+*n* (assuming that ES:DI still points to the array returned by either function); shifting it left by 2 bits and converting it to word by appending a low-order zero byte.

Function 42 (map page into system page frame) is the EEMS analog of EMS function 5. Function 5 may be used in EEMS to map a page into any window outside of DOS memory; that is, into a window whose address is returned by function 33. Function 42 maps pages into windows anywhere within the memory space, and must be used to map a page into a window within DOS memory—that is, a window for which the address is returned by function 41.

The next call, function 43 (get/set system mapping context) is similar in design to EMS function 15, but additional subfunctions have been added and the definition of the available page frames has been expanded to include all physical windows anywhere within the memory space. This set of subfunctions is designed to support multitasking monitors. Most of the subfunctions can be set to operate on only a subset of contiguous physical pages. Setting the CH register to the number of the starting physical page and the CL register to the total number of physical pages limits the effect of these functions on the specified physical pages. Setting CL to 0 (zero) causes all physical pages beginning at the number set in the CH register to be included in the operation.

Subfunctions 0 through 3 are similar to EMS function 15, except that they support the range setting with the CX register. Subfunctions 4 and 5 allow rapid switching between the two contexts of EEMS, reducing the amount of saving and restoring necessary.

Subfunction 6 deallocates the logical pages that were mapped during initialization to page frames within conventional memory. This subfunction is designed for use by multitasking managers that swap programs in conventional memory by paging. For example, suppose an EEMS board with 2MB (2,048KB, or 128 pages of 16KB) is installed in a system with 256KB of conventional memory. The memory-board switches are set to backfill conventional memory to 640KB. At initialization, the EEMM allocates 16 pages (384KB) and maps them into the windows that exist between 256KB and 640KB. Because the allocation was not requested by a program via interrupt 67H, no handle is assigned to this set of pages. The expanded-memory pool is now 112 pages.

When a multitasking manager subsequently starts up, it allocates pages to each process and maps those pages into the same windows between 256KB and 640KB. The contents of the original logical pages allocated by the EEMM are permanently lost, because their handle

TABLE 3: *EMS Status Code Summary*

ERROR CODE	ERROR DESCRIPTION
0	Normal return code, function executed successfully.
80H	Software error detected.
81H	Hardware error detected.
83H	Use of unallocated or invalid handle.
84H	Use of undefined function code.
85H	No handles available for allocation.
87H	Page count error, request exceeds total pages available.
88H	Page count error, insufficient unallocated pages available.
89H	Requested zero pages.
8AH	Logical page not available for this handle.
8BH	Physical page outside valid range.
8CH	Context stack out of memory.
8DH	This handle already has a saved context stack.
8EH	No context stack for specified handle.
8FH	Undefined subfunction code.

Every EMS/EEMS function returns a status value in AH upon completion. All programs using the EMM should check the returned AH value after each function call.

is not available to the manager. Without a handle, the manager can neither restore these pages to the windows in conventional memory nor deallocate them. Subfunction 6, however, allows the manager to deallocate some or all of these pages—return them to the free page pool—without a handle. In this way the multitasker can access the entire complement of expanded memory.

Finally, function 34 (generic accelerator card support) is a reserved function for use by manufacturers of caching accelerator boards. A caching board that runs an 80286 processor on a PC or an 80386 processor on a PC or an AT has a small amount (typically 8KB or 16KB) of high-speed, on-board memory. As data are read into the processor from slower main memory, they also are saved in the least-recently-used portion of the cache. If the same data are read again (for example, the instructions in a program loop), the data may be obtained at high speed without accessing the slower main memory.

Cached accelerator boards often have a problem when interacting with expanded memory, because the paging system changes data in main memory, but not in the cache. For example, if an EEMS application accesses logical page 10, which has been mapped to segment 8000H, some portion of the data from that page will be saved in the cache on the accelerator board. If a different logical page is then mapped to the same segment, the cache hardware will not be aware of the change. A subsequent access to the same physical address results in a cache hit and the wrong data are read from the accelerator board's cache. By forcing a cache flush whenever a page is remapped, Function 34 prevents this type of error. This function is not fully documented in the EEMS specification, but full details are available from AST Research, Inc.

DEVELOPER RESPONSIBILITIES

In developing applications that use EMS or EEMS memory, it is important to understand the interactions between the application program and the overall environment. Because applications can run in multitasking environments with resident programs—and sometimes even without real expanded-memory hardware—the applications developer must consider all current environments and consciously build in flexibility to adapt to future environments.

Every expanded-memory application should deallocate all memory in use before termination regardless of whether the program terminates normally. A critical error handler should be inserted in all applications to free its expanded memory in case of an abnormal termination (see "DOS Exception Handling," Dan Rollins, April 1987, p. 130). In addition, only the amount of expanded memory that is needed by the application should be allocated using as few handles as necessary; both the handles and memory should be freed as soon as possible so that more applications can run simultaneously in multitasked environments.

The performance of both emulated and real expanded-memory systems is affected primarily by the number of calls to the EMM; thus code should minimize these calls wherever possible. Developers should avoid mapping a single logical page into multiple physical pages: it renders an application unusable by anyone not using expanded-memory hardware, and emulators are becoming more common. In addition, not all emulators have the expanded memory provided by EMS/EEMS boards during device driver initialization.

Developers should also try to use expanded memory as if it were an extension of conventional memory. Although use of expanded memory involves a fair bit of effort on the part of the applications developer, the general public is convinced that expanded memory will allow more memory to be put into its machines. If applications support it only in a limited fashion, users may feel cheated.

EMPLOYING EMS FUNCTIONS

Listings 1 (EMDUMP.ASM) and 2 (EMMSTAT.ASM) are sample programs that use many common EMS function calls. Listing 3 (PRTPROC.ASM) contains some utility routines common to both programs. These programs, which were assembled using Microsoft Macro Assembler version 4.0, work with both LIM EMS and AQA EEMS hardware and LIM EMS emulators. EMDUMP contains a subroutine, EMSDUMP, that is used for debugging expanded-memory applications. EMMSTAT displays the registers that describe the current state of the EMM, or any other expanded-memory environment. Each program uses a different method to determine the presence of expanded memory.

Neither program is useful as a fully functional expanded-memory application: because they are provided primarily as examples of how an application program can interface to expanded memory, they do not include many of the error-handling routines and other precautions normally found in well-written programs. To be genuinely useful, each program should be tailored to a particular application as well as a specific hardware environment.

The first program, EMDUMP, verifies that expanded memory is present, allocates a page of expanded memory, fills each word of that page with its offset within the page, and then calls the EMSDUMP subroutine to display a page of expanded memory. EMSDUMP also saves the current context of expanded memory so that the memory can be used without disrupting the calling routine's use of expanded memory. After EMSDUMP dumps the contents of the page to the screen in hex, the context is restored and processing contin-

ues in the main routine to deallocate the page and terminate the program.

Note that EMDUMP was not created as a fully developed expanded-memory application program, and thus it does not take many precautions to assure appropriate use of expanded memory. If the application terminates abnormally, some expanded memory would be unavailable until the system was reset. However, the program does provide a useful model for many steps and techniques used in developing applications using expanded memory.

The program uses the get-interrupt-vector method to determine if expanded memory is present, but does not use the DOS get-interrupt-vector call to determine the segment address of the interrupt handler. Instead, it examines the actual address of interrupt 67H (0:19EH) for a segment register. After isolating the segment register, it tests for the presence of the EMM at the appropriate offset. If the EMM is not found, the program terminates. Reaching the label EMMHERE indicates that expanded memory is present in the system. After EMDUMP verifies that the hardware and software are functioning correctly, a single page is allocated and mapped into physical-page zero.

Once the logical page has been mapped, the program determines the address of physical-page zero by asking the EMM for the *base address*, a segment address that reflects the starting address of offset zero of physical-page zero. The code section FILLPAGE then fills each word in the expanded-memory page with its integer offset within the page. Once the page has been filled with a known set of values, EMSDUMP is called to display it.

Since the EMSDUMP subroutine can be inserted in an expanded-memory application at any time as a debugging aid, it tries to avoid modifying the state of any part of the system. All registers are saved and restored and the context is saved before EMSDUMP begins executing. EMSDUMP assumes that a handle will be passed in the DX register and that the number of the logical page that is to be dumped will be passed in the AX register.

After saving the expanded-memory context, EMSDUMP maps the logical page to be displayed into physical-page three of expanded memory. The subroutine then requests the page-segment base address and subsequently begins dumping memory. EMSDUMP uses the service routine PRTHEX to format the contents of the AX register into printable hex for later printing. The first call to PRTHEX formats the physical-page segment register. Because the page has been mapped to physical-page three, the data to be displayed start at the segment address returned by get base address and are offset by 0C000H.

Most of the remainder of the EMSDUMP subroutine establishes several loops to display all of the expanded-memory page a few lines at a time. After each 16 lines are displayed, the operator can either terminate the dump or continue displaying. At the label ENDUMP, EMSDUMP calls the EMM to restore the previous context of expanded memory, which restores physical-page three to its contents before the EMSDUMP subroutine was called.

The main program EMDUMP then deallocates the page and terminates the program. After an expanded-memory page has once been allocated, the DX register always contains the handle for expanded memory and EMDUMP can call the deallocate routine without first setting the handle.

EMMSTAT uses the open-handle method to determine the presence of

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expanded memory, then reports on the status of expanded memory. Although the information displayed by EMMSTAT is accurate for both EMS and EEMS environments, more information can and should be displayed to fully understand an EEMS environment.

EMMSTAT, then, follows the standard open-handle method described above, but it also attempts to distinguish between finding no expanded memory and having no DOS file handle available to open in order to verify the presence of expanded memory. Once it verifies the presence of the EMM, EMMSTAT makes an EEMS call to the EMM at label EMMPRESENT to determine whether the system holds EMS or EEMS memory. If EMS memory is present, the EEMS call returns an error code.

Then EMMSTAT displays the version number of the EMM in BCD format and describes the state of the memory, displaying the actual base address of the page frame, the number of pages both in the system and available for allocation, and the number of handles that are in use. The base address is of more interest in EMS than in EEMS systems: in EEMS systems, it is preferable to get the entire window-address array. The total number of pages in the system and the number available for use are usually the same and the number of handles in use is usually zero unless TSR applications or device drivers are using expanded memory; or, an application that terminated abnormally did not free its allocation of expanded memory. The number of handles in use would also be greater if EMMSTAT were invoked from within an application program such as Lotus 1-2-3.

After displaying all these statistics, EMMSTAT closes the DOS file handle used to determine the presence of expanded memory and terminates.

FUTURE EXPANSION

The future of expanded memory is unclear at this time. Expanded memory was originally developed to break the 640KB barrier but future versions of DOS may do that inherently, at least for 80286- and 80386-based machines.

Not many protected-mode applications have been developed. Instead, programmers continue to develop applications for existing machines and operating systems. In addition, because future versions of DOS are unlikely to perform well, if at all, on 8088 processors, demand will continue for more performance from existing PCs. While these existing machines may be replaced by 80286 or 80386 processors in some areas, few 8088 machines will be discarded. For this reason alone, the need for EMS hardware and applications that use expanded memory will continue. EEMS hardware offers genuine value to users of 8088, 80286, and 80386 processors for running applications developed for the 8088 systems: access to up to 8MB of memory and facilities to build effective multitasking environments for task switching within conventional-memory address space.

EMS may provide a bridge to applications for future operating systems. Applications developers can create programs capable of addressing more than 1MB of memory that can be adapted to future versions of DOS as they become available. Expanded memory has clearly met an existing need and is likely to continue to meet that need for at least a few more years.

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John A. Lefor is manager of technical services at the University of Rochester department of electrical engineering. Karen Lund is president of Tele-Ware Corporation. Mr. Lefor is coauthor of Tele-Ware's latest product, an EMS emulator package called Above DISC.

LISTING 1: ENDUMP.ASM

```
        PAGE    60,132
        TITLE   EMDUMP - DEMO OF SUBROUTINE TO DUMP EMS MEMORY

STACK       SEGMENT WORD STACK 'STACK'
            DB     100H DUP (?)
STACK       ENDS

DATA        SEGMENT WORD PUBLIC 'DATA'
HDRMSG       DB      0AH, 0DH, 'EMDUMP - Copyright 1987, '
             DB      'John A. Lefor',0AH, 0DH,'$'
EMMNAME      DB      'EMMXXXX0',0            ; NAME OF EMM
NOEMMMSG     DB      0AH, 0DH, 'Unable to locate EMM  - '
             DB      'EMDUMP terminates.$'
KEYHITMSG    DB      0AH, 0DH,'      Press any key to continue'
             DB      ' Esc to stop.$'
NOGETMSG     DB      0AH, 0DH, 'Insufficient memory to save context,'
             DB      ' EMDUMP Aborting.$'
ERRMSG       DB      0AH, 0AH, 0DH, 'EMM reports error code: '
ERRCODE      DB      'XX'
ERREND       DB      '.$'
DUMPLINE     DB    0AH, 0DH
DUMPSEG      DB    'XXXX:'
DUMPOFF      DB    'YYYY  '
DUMPWORD     DB    8 DUP('ZZZZ ')
             DB    '$'
CONTEXTLEN   EQU   128
CONTEXT      DB    CONTEXTLEN DUP(?)
DATA        ENDS

CODE        SEGMENT PUBLIC 'CODE'
            ASSUME CS:CODE,DS:DATA

FIVE         EQU     5
ESCAPE       EQU     27
DISPLAY      EQU     09H
SCREENFULL   EQU     16
PAGEFULL     EQU     (16*1024)/(SCREENFULL*16)
DOS          EQU     21H
KEYHIT       EQU     01H
DISPCHAR     EQU     02H
DOSOPEN      EQU     3DH
READ         EQU     00H                     ; ACCESS MODE IS READ ACCESS
COMPAT       EQU     00H                     ; FILE COMPATIBILITY MODE
TERMINATE    EQU     4CH                         ; TERMINATE PROCESS

EMM          EQU     67H
EMMSTATUS    EQU     40H
EMMVERSION   EQU     46H
EMMPAGECOUNT EQU     42H
EMMPAGEFRAME EQU     41H
EMMHANDLES   EQU     4BH
EMMMAP       EQU     44H
EMMALLOC     EQU     43H
EMMDEALLOC   EQU     45H
EMMGETSET    EQU     4EH
EMMGET       EQU     0
EMMSET       EQU     1
EMMSIZE      EQU     3
EMMSEG       EQU     00H
EMMOFF       EQU     019EH           ; OFFSET FOR INT67 SEGMENT

HDRNAME      EQU     0AH             ; LOCATION OF DRIVER NAME IN HDR

PAGEZERO     EQU     00H
PAGETHREE    EQU     03H

;   ESTABLISH IF AN EMM EXISTS IN THE SYSTEM USING
;   THE OPEN HANDLE METHOD

START:
           MOV     AX, DATA
           MOV     DS, AX                  ; LOAD DATA SEGMENT
           MOV     DX, OFFSET HDRMSG       ; DISPLAY COPYRIGHT NOTICE
           MOV     AH, DISPLAY
           INT     DOS

;   SEE IF EMS IS AVAILABLE USING THE INTERRUPT VECTOR METHOD

           MOV     AX, EMMSEG              ; PLACE SEGMENT ADDR
           MOV     ES, AX                  ; INTO ES REG
           MOV     BX, EMMOFF              ; EMM VECTOR OFFSET
           CLI                             ; DISABLE INTERRUPTS
           MOV     AX, ES:[BX]             ; GET SEGMENT REG OF INT
           STI                             ; RE-ENABLE INTERRUPTS
           MOV     ES, AX                  ; GET INTERRUPT SVC SEG
           MOV     DI, HDRNAME             ; ADDR OF DEV DRIVER NAME
           MOV     SI, OFFSET EMMNAME      ; DS:SI -> EMMXXXX0
           MOV     CX, 8                   ; FOR COMPARE
           REP     CMPSB                   ; IS IT EMM DEVICE
           JE      EMMHERE

;          IF NOT EMM, TERMINATE PROGRAM

           MOV     DX, OFFSET NOEMMMSG
           MOV     AH, DISPLAY
           INT     DOS
           JMP     END

EMMHERE:
;    EMS IS PRESENT, CHECK EMM STATUS THEN ALLOCATE
;    SPACE IN EXPANDED MEMORY.

           MOV     AH, EMMSTATUS           ; REQUEST STATUS
           INT     EMM                     ; CALL THE EMM
           OR      AH, AH                  ; TEST RC
           JZ      ALLOCMEM                ; IF ZERO, ALL IS WELL
           CALL    EMMERROR
           JMP     END                     ; IF ERROR, ALL DONE

ALLOCMEM:
           MOV     AH, EMMALLOC            ; REQUEST EMM PAGES
           MOV     BX, 1                   ; NEED ONLY ONE PAGE
           INT     EMM                     ; GET THE PAGE
           OR      AH, AH                  ; TEST RC
           JZ      MAPPAGE                 ; IF OK MAP THE PAGE
           CALL    EMMERROR                ; OTHERWISE DISPLAY ERROR
           JMP     END

;    TO FILL THE PAGE WE FIRST NEED THE BASE ADDRESS OF
;    THE PAGE, THEN WE MUST MAP IT INTO MEMORY.

MAPPAGE:
           MOV     AL,PAGEZERO             ; PLACE IN PAGE ZERO
           MOV     BX, 0                   ; USING PAGE ZERO
           MOV     AH, EMMMAP              ; MAP MEMORY
                                        ; DX IS STILL HANDLE FROM ALLOC
           INT     EMM                     ; CALL EMM
           OR      AH, AH                  ; TEST RC
           JZ      GETBASE                 ; IF OK, GET BASE ADDR
           CALL    EMMERROR
           JMP     END

GETBASE:
           MOV     AH, EMMPAGEFRAME        ; GET PF ADDRESS
           INT     EMM                     ; CALL EMM
           OR      AH, AH                  ; TEST RC
           JZ      FILLPAGE                ; IF ZERO, FILL THE PAGE
           CALL    EMMERROR                ; ELSE REPORT ERROR
           JMP     END

FILLPAGE:
           MOV     ES, BX                  ; ES -> PAGE FRAME
           MOV     BX, 0                   ; 0 IS INDEX THRU PAGE
           MOV     CX, (16*1024)/2         ; CX IS # OF WORDS
           MOV     AX, 0                   ; AX IS VALUE
LOOPAGE:
           MOV     ES:[BX], AX             ; PLACE VALUE IN EMS
           INC     AX
           INC     BX
           INC     BX                      ; -> NEXT WORD IN EMS
           LOOP    LOOPAGE                 ; LOOP THRU EMS

;   AN EMS PAGE HAS BEEN FILLED NOW DUMP EMS MEMORY

           MOV     AX, 0                   ; AX IS PAGE TO DUMP
                                           ; DX IS HANDLE TO DUMP
           CALL    EMSDUMP                 ; CALL DUMP ROUTINE

;   NOW THAT WE ARE DONE, DEALLOCATE THE PAGE USED
```

```
        MOV     AH, EMMDEALLOC          ; REQUEST DEALLOC
                                        ; DX HAS HANDLE
        INT     EMM                     ; CALL EMM
        OR      AH, AH                  ; TEST RC
        JZ      END
        CALL    EMMERROR
END:
        MOV     AL, 0                   ; ZERO RETURN CODE
        MOV     AH, TERMINATE           ; END PROGRAM
        INT     DOS
    PAGE
EMSDUMP     PROC    NEAR

;   ROUTINE TO DUMP TO THE SCREEN A PAGE OF EMS MEMORY
;           CALL EMSDUMP WITH
;                AX CONTAINING PAGE NUMBER
;                DX CONTAINING HANDLE

        PUSH    AX
        PUSH    BX
        PUSH    CX
        PUSH    DX
        PUSH    DI
        PUSH    ES

;   FIRST, SAVE THE CONTEXT OF THE EMM SO AS NOT TO UPSET
;   THE CALLERS USE OF EXPANDED MEMORY

        MOV     AH, EMMGETSET
        MOV     AL, EMMSIZE
        INT     EMM
        OR      AH, AH                  ; TEST RET CODE
        JZ      CHKSIZE
        CALL    EMMERROR
        JMP     END

CHKSIZE:
        CMP     AL, CONTEXTLEN          ; IS OUR CONTEXT ARRAY
                                        ; LARGE ENOUGH?
        JG      DOGET                   ; IF SO, DO THE GET
        MOV     DX, OFFSET NOGETMSG
        MOV     AH, DISPLAY
        INT     DOS
        JMP     END
DOGET:
        MOV     AH, EMMGETSET
        MOV     AL, EMMGET              ; GET EMM CONTEXT
        MOV     DI, OFFSET CONTEXT
        PUSH    DS
        POP     ES                      ; ES:DI -> CONTEXT ARRAY
        INT     EMM
        OR      AH, AH
        JZ      CONTEMD
        CALL    EMMERROR
        JMP     END

; NOW THE CONTEXT HAS BEEN SAVED, WE CAN MODIFY EXPANDED MEMORY

CONTEMD:
        MOV     BX, AX                  ; LOGICAL PAGE IN BX
        MOV     AL, PAGETHREE           ; PHYSICAL PAGE IN AL
        MOV     AH, EMMMAP              ; DO A MAP MEMORY
                                        ; HANDLE IN DX
        INT     EMM                     ; CALL EMM
        OR      AH, AH                  ; TEST RC
        JZ      GETADDR
        CALL    EMMERROR
        JMP     END

GETADDR:
        MOV     AH, EMMPAGEFRAME        ; REQUEST PAGE FRAME
        INT     EMM                     ; CALL EMM
        OR      AH, AH                  ; TEST RC
        JZ      DUMPPAGE
        CALL    EMMERROR
        JMP     END

DUMPPAGE:

;   PLACE THE PAGE FRAME SEGMENT IN DUMP LABEL

        MOV     AX, BX
        MOV     DI, OFFSET DUMPSEG
        CALL    PRTHEX

;   THE PAGE TO BE DUMPED IS IN PHYSICAL
;   PAGE THREE.  DUMP THE DATA TO THE SCREEN

        MOV     ES, BX                  ; ES -> PAGE FRAME
        MOV     BX, 0C000H              ; BX IS OFFSET WITHIN PAGE
        MOV     CX, PAGEFULL            ; NUMBER OF PAGES TO FILL
NEXTPAGE:
        PUSH    CX
        MOV     CX, SCREENFULL
NEXTLINE:
        PUSH    CX                      ; LOOP THRU A SCREEN
        MOV     AX, BX
        MOV     DI, OFFSET DUMPOFF
        CALL    PRTHEX
        MOV     CX, 8                   ; CX IS WORDS TO CONVERT
        MOV     DI, OFFSET DUMPWORD     ; DI -> OUTPUT LINE
DLINE:
        MOV     AX, ES:[BX]             ; AX IS WORD
        CALL    PRTHEX
        INC     BX                      ; -> NEXT WORD
        INC     BX
        ADD     DI, FIVE                ; -> NEXT DISPLAY
        LOOP    DLINE

;   THE LINE HAS BEEN FORMATTED, PRINT IT ON THE SCREEN

        MOV     DX, OFFSET DUMPLINE     ; DX -> LINE
        MOV     AH, DISPLAY             ; REQUEST PRINT
        INT     DOS

;       COME TO END OF LINE TRY TO FINISH A SCREEN

        POP     CX
        LOOP    NEXTLINE
        MOV     DX, OFFSET KEYHITMSG
        MOV     AH, DISPLAY
        INT     DOS
        MOV     AH, KEYHIT
        INT     DOS
        CMP     AL, ESCAPE
        JE      ENDUMP
        POP     CX
        LOOP    NEXTPAGE
        JMP     TERMDMP
ENDUMP: POP     CX

;   RESTORE EXPANDED MEMORY CONTEXT BEFORE RETURNING TO CALLED

        MOV     AH, EMMGETSET
        MOV     AL, EMMSET
        MOV     SI, OFFSET CONTEXT
        INT     EMM
        OR      AH, AH
        JZ      TERMDMP
        CALL    EMMERROR
        JMP     END

TERMDMP: POP    ES
        POP     DI
        POP     DX
        POP     CX
        POP     BX
        POP     AX
        RET
EMSDUMP ENDP
    PAGE
EMMERROR PROC   NEAR

;   ROUTINE TO DISPLAY EMM ERROR MESSAGES
;   PRESUMES AH CONTAINS THE ERROR CODE

        MOV     DI, OFFSET ERRCODE
        CALL    PRTHEX                  ; FORMAT THE HEX
        MOV     AX,'$.'
        MOV     WORD PTR ERREND, AX     ; TERMINATE MESSAGE
        MOV     DX, OFFSET ERRMSG
```

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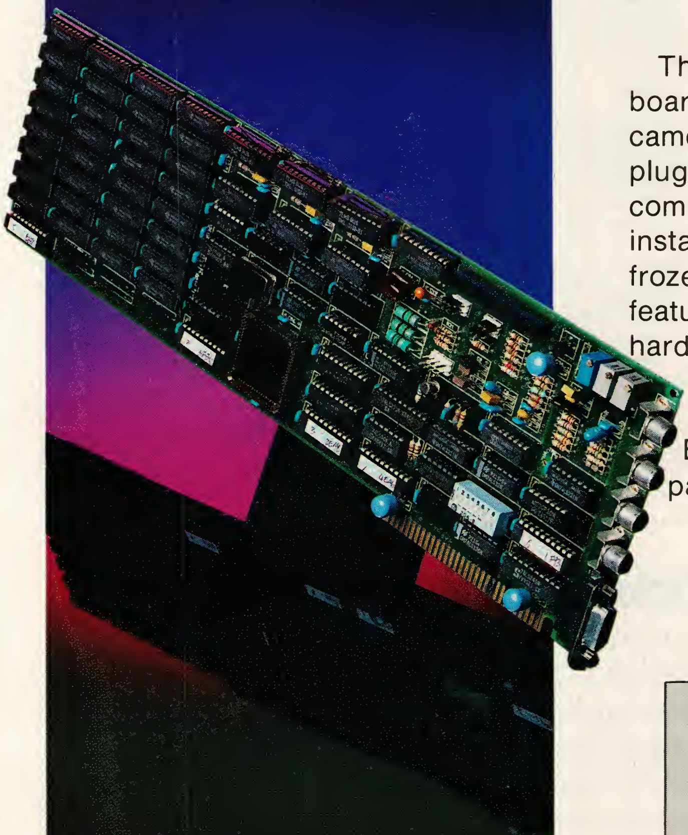

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CIRCLE NO. 238 ON READER SERVICE CARD

```
        MOV     AH, DISPLAY
        INT     DOS
        RET
EMMERROR    ENDP
INCLUDE PRTPROC.ASM         ; INSERT CONVERSION UTILITIES ROUTINES

CODE        ENDS
            END     START
```

LISTING 2: EMMSTAT.ASM

```
        PAGE    60,132
        TITLE   EMMSTAT - REPORT STATUSE OF EXPANDED MEMORY MANAGER

;   EMMSTAT - PROGRAM TO REPORT VARIOUS FACTS ABOUT THE CURRENT
;             STATUS OF THE EXPANDED MEMORY MANAGER.  THIS PROGRAM
;             MAKES USE OF A NUMBER OF EMM CALLS TO LOCATE, AND
;             VERIFY THE STATUS OF EMS AND EEMS VERSIONS OF EMM.

STACK       SEGMENT WORD STACK 'STACK'
            DB      100H DUP (?)
STACK       ENDS

DATA        SEGMENT WORD PUBLIC 'DATA'
EMMHANDLE       DW      ?                   ; HANDLE FROM OPENING EMM
EMMNAME         DB      'EMMXXXX0',0            ; NAME OF EMM
PHYS_WINDOW     DB      64 DUP(?)           ; PHYSICAL WINDOW ARRAY
HDRMSG          DB      0AH, 0DH, 'EMMSTAT - Copyright, 1987  '
                DB      'John A. Lefor', 0AH, 0DH,'$'
NOHANDLEMSG     DB      0AH, 0DH, 'Unable to test for EMM - '
                DB      'No file handles available.$'
NOEMMMSG        DB      0AH, 0DH, 'Unable to locate EMM - '
                DB      'Expanded Memory not present in system.$'
NOTREADY        DB      0AH, 0DH, 'EMM present but not Ready, '
                DB      'Reboot system.$'
EMSEMM          DB      0AH, 0DH, 'EMS Expanded Memory Manager '
                DB      'present in system.$'
EEMSEMM         DB      0AH, 0DH, 'EEMS Expanded Memory Manager '
                DB      'present in system.$'
PAGEMSG         DB      0AH, 0DH, 'Total Memory Pages in system: $'
AVAILPAGES      DB      0AH, 0DH, 'Total Memory Pages available: $'
VERSIONMSG      DB      0AH, 0AH, 0DH, 'EMM Version: $'
PFMSG           DB      0AH, 0DH, 'Page Frame Segment: '
PFADDR          DB      'XXXX$'
HANDLEMSG       DB      0AH, 0DH, 'Handles in use: $'
ERRMSG          DB      0AH, 0AH, 0DH, 'EMM reports error code: '
ERRCODE         DB      'XX'
ERREND          DB      '.$'
DATA        ENDS

CODE        SEGMENT BYTE PUBLIC 'CODE'
            ASSUME CS:CODE,DS:DATA

DISPLAY     EQU     09H
DOS         EQU     21H
DISPCHAR    EQU     02H
DOSOPEN     EQU     3DH
HANDLERR    EQU     4                   ; ERROR RETURN - NO HANDLES
DOSCLOSE    EQU     3EH
READ        EQU     00H                 ; ACCESS MODE IS READ ACCESS
COMPAT      EQU     00H                 ; FILE COMPATIBILITY MODE
IOCTL       EQU     44H
GETDEVINFO  EQU     00H                 ; REQUEST DEVICE INFORMATION
GETOUTSTAT  EQU     07H                 ; REQUEST OUTPUT STATUS
DEVFLAG     EQU     80H                 ; DEVICE FLAG IN DEVICE INFO
TERMINATE   EQU     4CH                 ; TERMINATE PROCESS
WINDOW_ARRAY EQU    60H                 ; GET STD PHYS WINDOW ARRAY

EMM         EQU     67H
EMMSTATUS   EQU     40H
EMMVERSION  EQU     46H
EMMPAGECOUNT EQU    42H
EMMPAGEFRAME EQU    41H
EMMHANDLES  EQU     4BH

;       ESTABLISH IF AN EMM EXISTS IN THE SYSTEM USING
;       THE OPEN HANDLE METHOD
```

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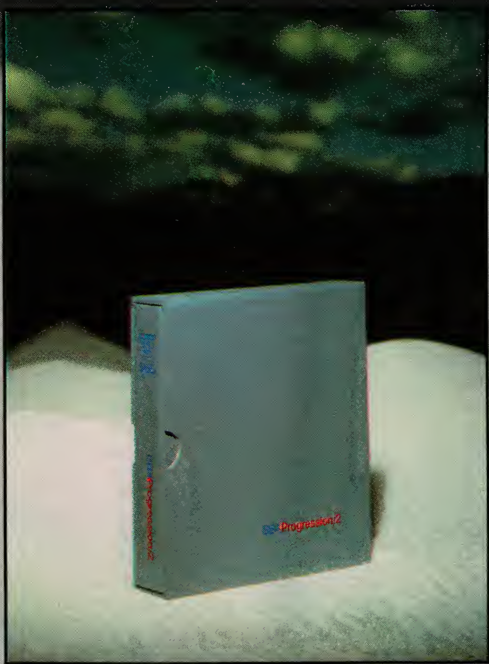

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CIRCLE NO. 133 ON READER SERVICE CARD

```
START:
        MOV     AX, DATA
        MOV     DS, AX                  ; LOAD DATA SEGMENT
        MOV     DX, OFFSET HDRMSG
        MOV     AH, DISPLAY
        INT     DOS
        MOV     DX, OFFSET EMMNAME      ; -> NAME OF EMM
        MOV     AH, DOSOPEN             ; REQUEST AN OPEN
        MOV     AL, READ+COMPAT
        INT     DOS                     ; CALL DOS
        JNC     TESTFILE                ; IF OK, TEST FOR FILE

;       OPEN FAILED, EMM NOT PRESENT OR NO HANDLES AVAILABLE

        CMP     AX, HANDLERR            ; WAS IT HANDLE ERROR?
        JNE     NOEMMERR
        MOV     DX, OFFSET NOHANDLEMSG
        JMP     NOHANDERR
NOEMMERR: MOV   DX, OFFSET NOEMMMSG     ; POINT TO MESSAGE
NOHANDERR: MOV  AH, DISPLAY             ; REQUEST MSG DISPLAY
        INT     DOS                     ; CALL DOS
        JMP     END

;       TEST FOR FILE OR DEVICE DRIVER

TESTFILE:
        MOV     EMMHANDLE, AX       ; SAVE HANDLE FOR CLOSE LATER
        MOV     BX, AX                  ; PLACE HANDLE IN BX
        MOV     AH, IOCTL               ; IOCTL REQUEST
        MOV     AL, GETDEVINFO
        MOV     CX, 0                   ; NO BYTES TO MOVE
        INT     DOS                     ; CALL DOS
        JNC     CHKBIT7                 ; IF OK, NEED TO CHECK

;       IOCTL FAILED, PRESUME EMM NOT PRESENT

        MOV     DX, OFFSET NOEMMMSG     ; POINT TO MESSAGE
        MOV     AH, DISPLAY             ; REQUEST DISPLAY
        INT     DOS                     ; DISPLAY MESSAGE
        JMP     END

CHKBIT7:
        AND     DX, DEVFLAG             ; TEST FOR DEVICE FLAG
        JNZ     TESTSTATUS              ; IF PRESENT TEST STATUS

;       OPEN FOUND A FILE, EMM NOT PRESENT

        MOV     DX, OFFSET NOEMMMSG     ; POINT TO MESSAGE
        MOV     AH, DISPLAY             ; REQUEST DISPLAY
        INT     DOS                     ; CALL DOS
        JMP     END

;       NOW TEST DEVICE DRIVER STATUS

TESTSTATUS:
        MOV     AH, IOCTL               ; IOCTL CALL
        MOV     AL, GETOUTSTAT          ; REQUEST OUTPUT STATUS
        MOV     CX, 0                   ; NOTHING TO MOVE
        INT     DOS                     ; CALL DOS
        JNC     CHKSTAT

;       IOCTL FAILED, PRESUME EMM NOT PRESENT

        MOV     DX, OFFSET NOEMMMSG     ; POINT TO MESSAGE
        MOV     AH, DISPLAY
        INT     DOS                     ; DISPLAY MESSAGE
        JMP     END

;       TEST RETURN FROM IOCTL FOR READY STATUS

CHKSTAT:
        CMP     AL, 0FFH                ; STATUS OK?
        JE      EMMPRESENT

;       STATUS NOT AS EXPECTED, EMM NOT READY

        MOV     DX, OFFSET NOTREADY     ; POINT TO MESSAGE
        MOV     AH, DISPLAY
        INT     DOS                     ; DISPLAY MESSAGE
        JMP     END
```

```
;       EMM IS PRESENT, NOW DETERMINE IF IT IS EMS OR EEMS
;       DO THIS BY ISSUING AN EEMS CALL (FUNCTION CODE 60H)
;       AND TEST THE RETURN CODE.  IF INVALID RETURN CODE
;       MUST BE EMS, OTHERWISE IS EEMS.

EMMPRESENT:
        MOV     AH, WINDOW_ARRAY        ; GET STD PHYS WINDOW ARRAY
        PUSH    DS                      ; SAVE DATA SEGMENT ADDR
        POP     ES                      ; PLACE IN ES FOR CALL
        MOV     DI, OFFSET PHYS_WINDOW  ; WINDOW ARRAY HERE
        INT     EMM                     ; CALL EMM
        OR      AH,AH                   ; TEST RETURN CODE
        JZ      FOUNDEEMS               ; IF ZERO WE HAVE EEMS

;       BAD RETURN FROM EMM, WE MUST HAVE AN EMS SYSTEM

        MOV     DX, OFFSET EMSEMM       ; SET MESSAGE
        MOV     AH, DISPLAY
        INT     DOS                     ; DISPLAY MESSAGE
        JMP     GETVERSION

FOUNDEEMS:
        MOV     DX, OFFSET EEMSEMM      ; SET MESSAGE
        MOV     AH, DISPLAY
        INT     DOS                     ; DISPLAY MESSAGE

;       GET THE VERSION LEVEL OF THE EMM

GETVERSION:
        MOV     AH, EMMVERSION          ; REQUEST VERSION #
        INT     EMM                     ; CALL EMM
        OR      AH,AH                   ; TEST RETURN CODE
        JZ      SHOWVERSION
        CALL    EMMERROR
        JMP     END

SHOWVERSION:
        PUSH    AX                      ; SAVE VERSION
        MOV     DX, OFFSET VERSIONMSG
        MOV     AH, DISPLAY
        INT     DOS
        POP     AX
        PUSH    AX                      ; SAVE FOR NEXT DIGIT
        AND     AX, 00F0H               ; ISOLATE MAJOR VER #
        MOV     CL, 4                   ; SHIFT TO LOW BITS
        SHR     AX, CL
        CALL    PRTDEC                  ; PRINT MAJOR VER #
        MOV     AH, DISPCHAR
        MOV     DL,'.'
        INT     DOS                     ; PRINT A PERIOD
        POP     AX                      ; GET EMM VERSION
        AND     AX, 000FH               ; ISOLATE MINOR VERSION
        CALL    PRTDEC                  ; PRINT MINOR VERSION

;       GET THE ADDRESS OF THE PAGE FRAMES FOR DISPLAY

        MOV     AH, EMMPAGEFRAME        ; REQUEST PF ADDRESS
        INT     EMM                     ; CALL EMM
        OR      AH, AH                  ; TEST RETURN CODE
        JZ      SHOWPF_ADDR
        CALL    EMMERROR
        JMP     END

SHOWPF_ADDR:
        MOV     DI, OFFSET PFADDR
        MOV     AX, BX                  ; PLACE ADDRESS IN AX
        CALL    PRTHEX                  ; DISPLAY ADDRESS
        MOV     DX, OFFSET PFMSG        ; DISPLAY MESSAGE
        MOV     AH, DISPLAY
        INT     DOS

GETSIZE:

;       THERE IS AN EMS OR EEMS MANAGER PRESENT TEST FOR AMOUNT
;       OF EXPANDED MEMORY ON THE MEMORY BOARD(S).

        MOV     AH, EMMPAGECOUNT
        INT     EMM                     ; CALL THE EMM
```

```
         OR      AH, AH                  ; TEST FOR ERRORS
         JZ      SHOWPAGE
         CALL    EMMERROR
         JMP     END

SHOWPAGE:
         PUSH    DX                      ; SAVE PAGE INFO
         MOV     DX, OFFSET PAGEMSG      ; DISPLAY PAGES
         MOV     AH, DISPLAY
         INT     DOS                     ; DISPLAY MESSAGE
         POP     AX                      ; RECOVER TOTAL PAGES
         CALL    PRTDEC                  ; DISPLAY # OF PAGES
         MOV     DX, OFFSET AVAILPAGES
         MOV     AH, DISPLAY
         INT     DOS
         MOV     AX, BX                  ; DISPLAY PAGES AVAILABLE
         CALL    PRTDEC

;        DISPLAY NUMBER OF HANDLES IN USE

         MOV     AH, EMMHANDLES          ; REQUEST # OF HANDLES
         INT     EMM                     ; CALL EMM
         OR      AH, AH                  ; TEST RETURN CODE
         JZ      SHOWHANDLES
         CALL    EMMERROR
         JMP     END

SHOWHANDLES:
         MOV     DX, OFFSET HANDLEMSG    ; SET MESSAGE
         MOV     AH, DISPLAY
         INT     DOS                     ; PRINT MESSAGE
         MOV     AX, BX                  ; HANDLE COUNT IN AX
         CALL    PRTDEC                  ; PRINT THE MESSAGE

END:
;        BEFORE TERMINATING, CLOSE THE EMM HANDLE SET DURING OPEN

         MOV     BX, EMMHANDLE           ; SET THE HANDLE
         MOV     AH, DOSCLOSE
         INT     DOS
         MOV     AL, 0                   ; ZERO RETURN CODE
         MOV     AH, TERMINATE           ; END PROGRAM
         INT     DOS
      PAGE
EMMERROR   PROC  NEAR

;        ROUTINE TO DISPLAY EMM ERROR MESSAGES
;        PRESUMES AH CONTAINS THE ERROR CODE

         MOV     DI, OFFSET ERRCODE
         CALL    PRTHEX                  ; FORMAT THE HEX
         MOV     AX,'$.'
         MOV     WORD PTR ERREND, AX     ; TERMINATE MESSAGE
         MOV     DX, OFFSET ERRMSG
         MOV     AH, DISPLAY
         INT     DOS
         RET
EMMERROR   ENDP

INCLUDE PRTPROC.ASM          ; INSERT CONVERSION ROUTINES

CODE       ENDS
           END   START
```

LISTING 3: PRTPROC.ASM

```
; ROUTINE TO CONVERT 1 WORD TO ASCII DIGITS
; BY JOHN A. LEFOR

;    AX IS PRINTED

PRTDEC     PROC  NEAR

         PUSH    DS
         PUSH    DI
         PUSH    DX
         PUSH    CX
         PUSH    AX              ; SAVE REGS
         LEA     DI, CS:TBUFF    ; DI -> PRINT BUFFER
         MOV     DX, AX          ; ARG PASSED IN AX
         MOV     CX, 0           ; TRACK FOR # OF DIGITS
OUT1:
         PUSH    CX
         MOV     AX, DX          ; PLACE NUMBER IN AX
         MOV     DX, 0
         MOV     CX, 10
         DIV     CX              ; DIVIDE BY 10
         XCHG    AX, DX          ; GET REMAINDER IN AX
         ADD     AL, 30H         ; CONVERT TO ASCII
         MOV     CS:[DI], AL     ; PLACE IN CHAR BUFFER
         INC     DI              ; -> NEXT SPOT IN BUFFER
         POP     CX              ; COUNT NUMBER OF DIGITS
         INC     CX
         CMP     DX,0            ; ANYTHING LEFT
         JNZ     OUT1            ; IF MORE, LOOP ON
OUT2:
         DEC     DI              ; DI -> NEXT DIGIT
         MOV     DL, CS:[DI]     ; GET THE DIGIT
         MOV     AH, DISPCHAR
         INT     DOS             ; PRINT THE DIGIT
         LOOP    OUT2            ; LOOP THRU ALL DIGITS
         POP     AX              ; RESTORE REGS
         POP     CX
         POP     DX
         POP     DI
         POP     DS              ;REGS RESTORED
         RET
TBUFF    DB      0,0,0,0,0
PRTDEC  ENDP
        PAGE

;       PRTHEX ROUTINE CONVERTS HEX DATA IN AX TO HEX CHARACTERS
;               RESULT -> BY DS:DI

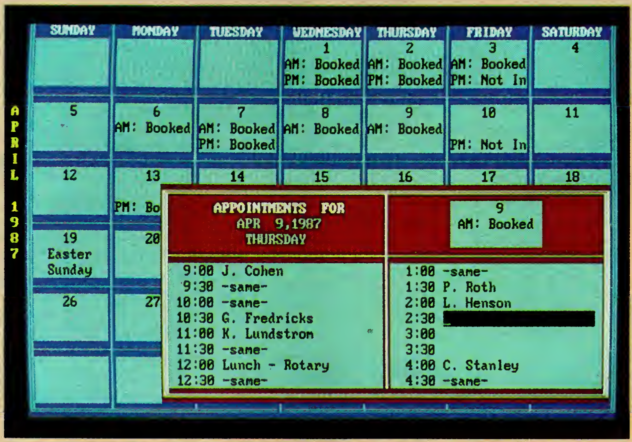
;       ADAPTED FROM "ADVANCED MS-DOS" BY RAY DUNCAN,
;       MICROSOFT PRESS, 1986.

PRTHEX    PROC    NEAR
          PUSH    DI
          PUSH    AX
          PUSH    CX
          PUSH    AX
          MOV     AL,AH
          CALL    CONV_BYTE       ; CONVERT UPPER BYTE
          POP     AX
          CALL    CONV_BYTE       ; CONVERT LOWER BYTE
          POP     CX
          POP     AX
          POP     DI
          RET
PRTHEX    ENDP

CONV_BYTE PROC    NEAR
          SUB     AH,AH           ; CLEAR UPPER BYTE
          MOV     CL,16
          DIV     CL              ; DIVIDE BINARY DATA BY 16
          CALL    MAKPRT          ; MAKE A PRINTABLE CHAR
          PUSH    ES
          PUSH    DS
          POP     ES
          STOSB
          MOV     AL,AH
          CALL    MAKPRT          ; THE REMAINDER IS NEXT DIGIT
          STOSB
          POP     ES
          RET
CONV_BYTE ENDP

MAKPRT    PROC    NEAR
          ADD     AL,'0'          ; CONVERT BOTTOM 4 BITS IN AL
          CMP     AL,'9'          ; IS IT A CHARACTER
          JLE     ENDPRT
          ADD     AL,'A'-'9'-1    ; FIX THE CHARACTERS
ENDPRT:
          RET
MAKPRT    ENDP
```

BOB STANTON HAD A GREAT IDEA. AN HOUR LATER HE WAS TESTING IT.



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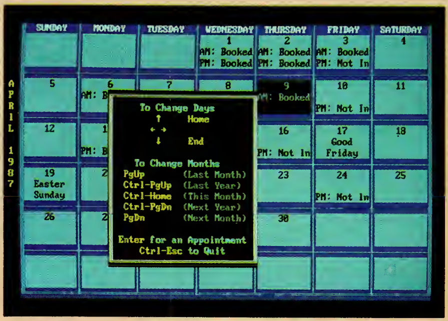
So here are Bob's appointment screens. You can see the source listing to the right. We marked all the code Screener wrote for him.



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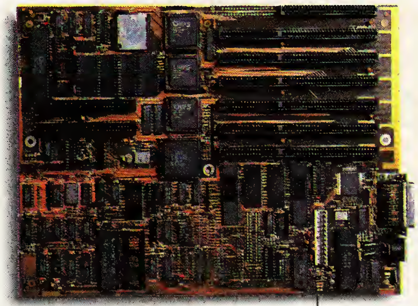

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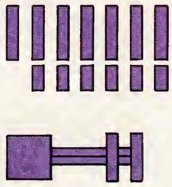

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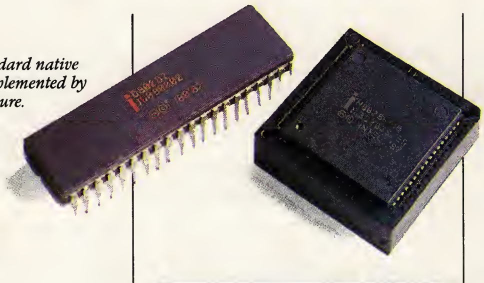

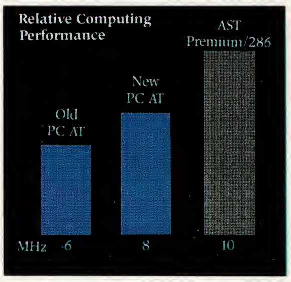

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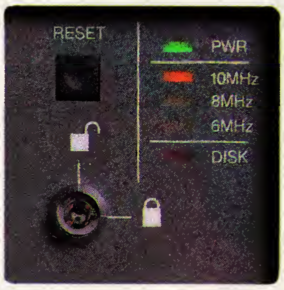

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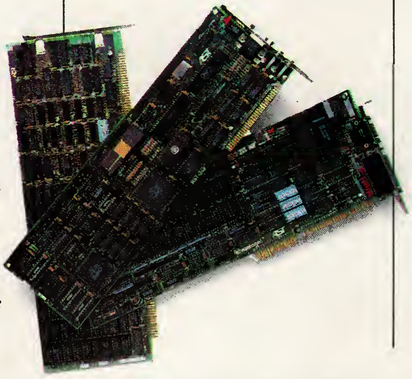

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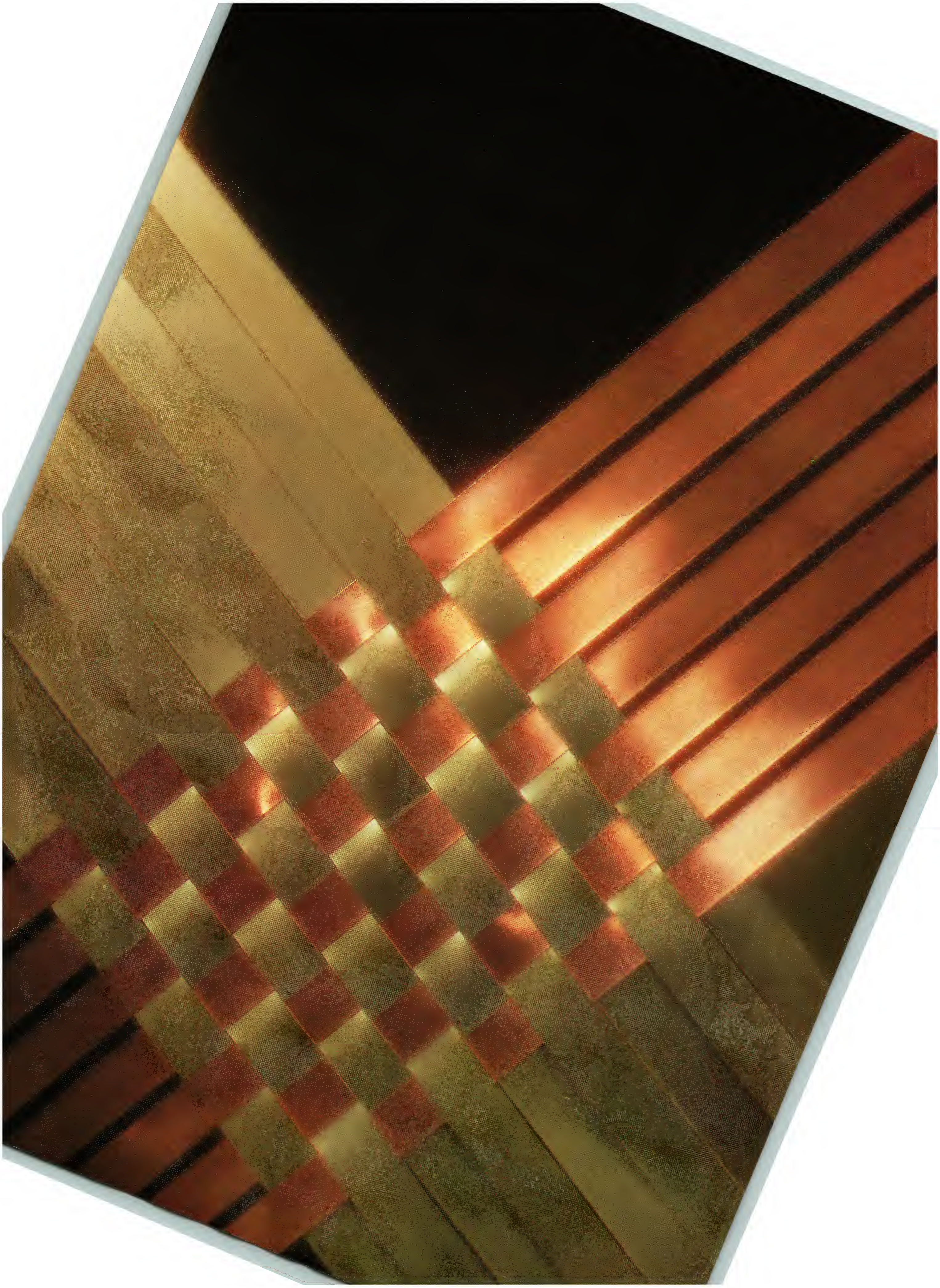


Elegant Linkage

RICHARD HALPERN

Some elegant techniques are available for linking external assembly language routines directly into Turbo Pascal programs.

The power and flexibility of Borland's Turbo Pascal notwithstanding, programming situations arise when it should be abandoned in favor of assembly language. It takes assembly language, for example, to exploit the advanced features of the new, albeit nonstandard, graphics boards. The abandonment, however, does not have to be total. The major part of a problem can be solved in Pascal, with assembly language subroutines handling specialized tasks. This article considers the problem of linking such subroutines into Turbo Pascal programs. Along the way, some corrections are suggested to the Turbo Pascal manual (version 3.0).

The process of subroutine linkage has three basic requirements. First, the Pascal program must be informed that the routine is external; second, a mechanism must be present for passing parameters; and third, the assembly language routine must adhere to rules laid down by Turbo Pascal. The second point requires familiarity with the internal representation of data in Turbo Pascal (see the accompanying sidebar, "Data Representation in Turbo Pascal").

The main program must declare that the subroutine code is external and indicate where that code can be found. A slight modification of the usual function or procedure headings is required. A sample procedure heading follows:

```
PROCEDURE TEST(X,Y:INTEGER);
  EXTERNAL 'SUB.COM';
```

The usual heading is followed by the word EXTERNAL, which is followed by the name of an executable file in which the routine can be found. If the subroutine is a .COM file, it is acceptable to leave off the file extension.

The responsibility for parameter passing is shared by Turbo Pascal and the programmer. Turbo's job is to set up areas for input and output. The programmer's job is to implement the protocols for retrieving the input and delivering the output. The stack is central to many of the operations, although certain memory locations, registers, and even an 8088 flag play a role.

PHOTOGRAPH • WALTER LARRIMORE/BLAKESLEE-LANE

Before the main program relinquishes control to the subroutine, it pushes all parameters onto the stack in the order they appear in the heading. In the case of a VAR parameter, the doubleword address of the first byte of the parameter is pushed—segment, then offset. For a value parameter, the value itself is pushed. The two exceptions to this rule are records and arrays, which are passed as VAR parameters regardless of how they are declared. It is the programmer's responsibility to access the variable and copy the array and/or record for local use.

After all parameters have been pushed, a one-word return address is pushed onto the stack. Figure 1 shows the stack immediately after the following sample procedure takes control:

```
PROCEDURE  EX1(VAR V1: INTEGER;
               V2: INTEGER;
               V3: ANY_SET;
               V4: STRING6
              );
```

Procedure and function outputs are handled differently. In Turbo Pascal, a procedure outputs through its VAR parameters. Thus, the assembly language routine need only locate those parameters (their addresses are on the stack) and write to them. Functions output through the function name. The mechanics of this process at the assembly language level depend on the data type:
Integers, subranges, and enumerated types. These types are returned in AX. If a result can be contained in one byte, it is returned in AL (with AH zeroed out).
Booleans. Although normally stored in a byte, Booleans are returned by setting the 8088 Z-flag if the value is false.
Reals, strings. These types are returned on the stack, as shown in figure 2, with

DATA REPRESENTATION IN TURBO PASCAL

The Turbo Pascal choices for representing data types normally are not a concern of the Pascal programmer. However, when an assembly language routine is being interfaced, interpreting the data representation is essential. The intricacies of Turbo Pascal data types are described here.
Integers. Integers are stored as two-byte, two's-complement numbers. The least significant byte (LSB) is stored at the lower address.
Characters and Booleans. Characters are stored as one-byte ASCII codes. Booleans are stored as one-byte values (0 = false, 1 = true).
Strings. A string of length L bytes occupies L+1 bytes of memory. The first byte is the length of the string in bytes. The length byte is treated as an unsigned integer, therefore the maximum length string is 255 characters. The subsequent bytes, at higher addresses in memory, represent the characters in the string.
Real numbers. The treatment of real numbers in Turbo Pascal is complicated by there being three versions of Turbo: standard, BCD (binary-coded decimal), and 8087. The standard version has a six-byte real number; the BCD version has a ten-byte real, and is most often used for business applications; and the 8087 version uses the eight-byte 8087 representation for reals. It is essential that an assembly language routine using real numbers "know" the type of reals being used, and handle them appropriately.
Enumerated types and subranges. An enumerated type is stored as an integer equal to its ordinal value in the declaration. The first one is stored as a 0, the next as a 1, and so on. A subrange, on the other hand, is stored as its ordinal value in the full range, not the subrange. For example, from the following Pascal declarations:

```
VAR  w: (mon, tue, wed, thu, fri, sat, sun);
     x: fri .. sun;
     y: 3 .. 7;
     z: 'b' .. 'g';
```

the sample storage arrangements would be as follows:

```
w := fri   stored as a 5
x := fri   stored as a 5, not a 0
y := 3     stored as a 3, not a 0
z := 'b'   stored as a 97,
           its ASCII (ordinal) value
```

Sets. Turbo Pascal stores a set as an *n*-byte field, where *n* ranges from 1 to 32. The value of *n* depends upon the size of the set and the ordinal values of the upper (MAX) and lower (MIN) bounds of the set. Basically, each possible member of a set is represented by a unique bit in the field. If an element is a member, the corresponding bit of the field is 1.

The value of *n* is calculated and a bit associated with an element in the following manner. Consider, for example, a set of the first eight ASCII characters. Obviously, this can be represented with one byte. If V is the ordinal value of an element, then the bit representing that element is

bit = V mod 8

Now, consider a set of the first 10 ASCII characters. Clearly, two bytes will be needed. The first byte is for ASCII 0 to ASCII 7; the second byte is for ASCII 8 and 9. The bit formula above is used for each byte. These two examples are intuitively sound.

Next, consider a set of the 10 ASCII characters 7 to 16. Three bytes will be needed instead of two: The first byte uses one bit for ASCII 7, with the other bits always 0. The second byte is for ASCII 8 to ASCII 15. The third byte uses one bit for ASCII 16, with the others always 0. To further understand, think of a set as temporarily occupying 32 bytes, then define upper and lower bounds of a subfield as follows:

```
upper bound = MAX DIV 8
  lower bound = MIN DIV 8
```

This is an *n*-byte field where

N = MAX DIV 8 − MIN DIV 8 + 1

The byte number for a given element falls somewhere in the range *byte number = V DIV 8* (the individual bits are set as indicated previously). For a given set, Turbo Pascal normally stores only the bytes that comprise the subfield defined above. All other bytes contain only 0s, and would be pointless to store. However, if a set is a value parameter for a subroutine, the full 32-byte field is passed.
Pointers. A pointer is stored as a doubleword: offset, then segment.
Records. The address of a given field depends upon the order of declaration within the record, the lowest address belonging to the first field. For a fixed record, the amount of storage is the sum of the amounts required by all the fields. For a variant record, the amount required is the sum of the fixed part, plus the amount required by the largest possible variant. Regardless of the size of the variant, each item in it starts at the same address.
Arrays. Arrays are stored in row-major order, so that for an array that is declared A[4,3], element A[1,2] follows A[1,1]. The individual array components are stored according to the descriptions given above.

—Richard Halpern

one additional requirement: Turbo Pascal will not find the output unless SP is left pointing to the first byte of the function result. (This will be illustrated explicitly in an example below.)

Pointers. Pointers are returned in the DX:AX register pair; DX holds the segment and AX holds the offset.

Although the Turbo Pascal manual includes a discussion on returning sets on the top of the stack, Pascal as a language (including Turbo) does not permit a function to return a set.

ASSEMBLY CONSIDERATIONS

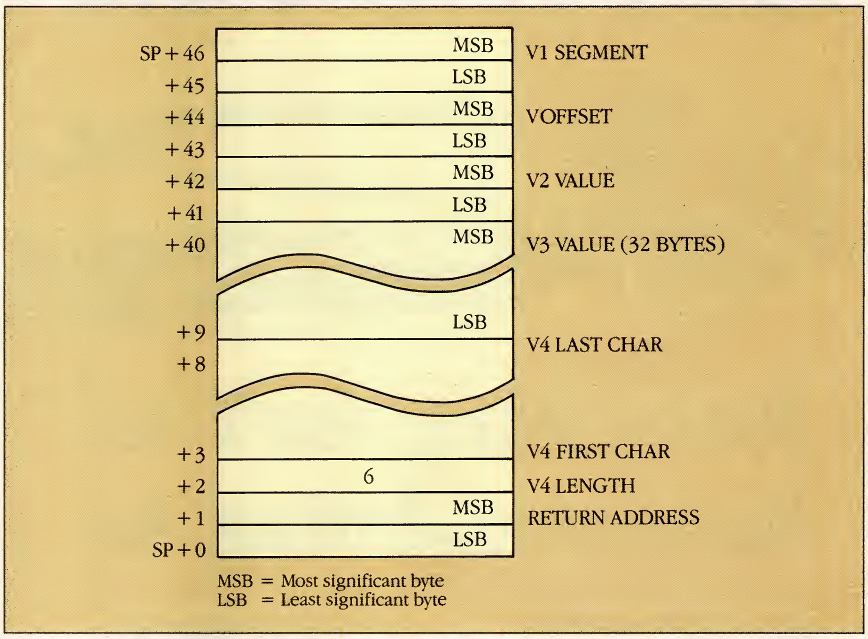
Three issues pertain to the assembly language routine itself, the first being the type of executable file needed. Recall that any assembly language source code can be processed into one of two executable types, .COM and .EXE. The .COM file is ready to run—it is code that has been written, but in machine language. DOS simply loads it into a single segment (the code segment) and uses as addresses the offsets calculated by the linker. A .COM file is said to be *code-segment relocatable.*

A .EXE file, which is the output of the linker, usually has references to several segments. Such references cannot be resolved by the linker. The structure of a .EXE file reveals the fact that it is a module consisting of the object code plus a .EXE header. At load time, DOS inspects the .EXE header to resolve the segment references, then discards it and loads the code. If the routine happens to be code-segment relocatable, then the header information is unnecessary and can be removed. This is the mechanism at work when a .EXE file is converted to a .COM file with EXE2BIN.

Turbo Pascal compiles the source code to a .COM file. As it compiles, it incorporates the subroutine's object code into its object code. Hence, the subroutine also must be code-segment relocatable. Furthermore, the subroutine must be stripped of the .EXE header, or Turbo will not link it. If the subroutine is made a .COM file, it will meet these requirements, but this is not essential. Any subroutine converted by EXE2BIN without error messages will be code-segment relocatable.

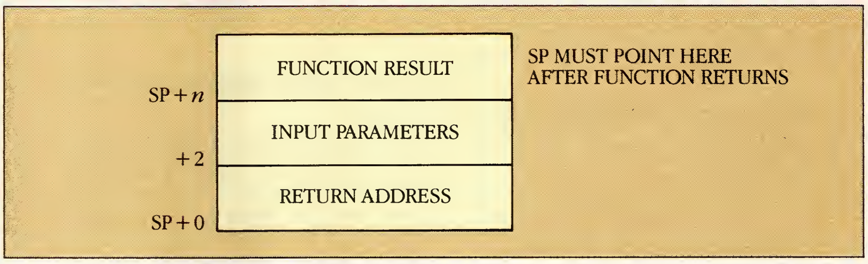
Saving the appropriate registers is another issue. The Turbo Pascal manual recommends saving the BP, CS, DS, and SS registers immediately upon entry and restoring them before exiting. This normally is accomplished using PUSH and POP instructions. The inclusion of CS in this list is therefore puzzling, because a POP CS command cannot be issued. Certainly any register that is used by the subroutine should be saved and restored (the DS and BP registers usually fall within this category).

FIGURE 1: *Parameter Passing*



Upon entry to procedure EX1 (the code for which is provided in text), the stack is organized as above. Register SP points to the procedure return address.

FIGURE 2: *Returning a STRING or a REAL*



Turbo Pascal reserves an area above the parameters. The function value is placed there, and the stack pointer is left pointing to this area when the function exits.

The final consideration is manipulation of the parameters once they have been passed. Details are offered in the examples, but a few preliminary remarks are in order. It is essential to have a location on the stack that can serve as a reference point. When the subroutine takes control, the SP register points to the return address. However, because SP changes with each PUSH and POP, it is not a reliable anchor. Thus, one of the first acts of a subroutine is to save the SP register in BP. Because the contents of BP are an offset into the stack segment, an expression of the form [BP+n] can be used to point to any location on the stack. A similar procedure can be done with the BX register. If the segment address of a variable parameter is loaded into DS, and its offset is loaded into BX, then [BX+n] points to the nth byte from the beginning of the parameter.

PARAMETERS AND THE STACK

The following examples illustrate how parameters are handled with the stack. Each consists of a short Turbo Pascal program that passes a quantity to a subroutine and tests to verify that all went as expected. The assembly language modules perform simple tasks: they are intended only to demonstrate functions, procedures, and some parameter types that need clarification. Each program was compiled by Turbo Pascal into a .COM file. The first example is described in detail, the others in terms of the new components they introduce.

Example one (figure 3). The Pascal program calls an assembly language procedure to reverse the order of characters in an input string. In the procedure,

line 1 (MOV BP,SP) saves the current value of SP in the BP register; BP is now the reference. Looking at the stack organization (shown as it is just after line 1 executes) reveals that ST3 (the input) is at the bottom and occupies four bytes. The byte in ST3 closest to the stack top contains the characters of the string itself. (Note that the length is *not* just above the last character, as indicated in the Turbo Pascal manual.)

Working upwards, the stack holds the address of the variable parameter (ST4), the one-word return address, and finally the saved registers. The word at [BP+14] is the segment address of ST4 (the output); procedure lines 2 and 3 store this in DS. The word at [BP+12] is the offset of ST4; line 4 puts that in BX. Because the contents of BX are an offset into the data segment, the expression [BX] now references the first byte of ST4, which is the string length; [BX+1] references the first character, and so on. As for ST3, its three characters are on the stack at locations [BP+17] through [BP+19]. Line 5 puts the string length into the first byte of ST4, and lines 6 through 11 transfer three characters from ST3 to ST4 in reverse order. Now the subroutine has completed its job: it has placed information in locations [BX] through [BX+3], where Turbo expects to find the output. The remaining lines restore the saved registers, then return control to the main program. This subroutine is in the form required by EXE2BIN for conversion to a .COM file (with ORG 100H and START labels).

Example two (figure 4). This program performs the same task as the one in figure 3, but it uses a function. The techniques for accessing the parameters are unchanged, but the stack is different. At the bottom is a four-byte area in which Turbo expects to find the output of the function. Just on top of that is input ST2, then the return address, and the saved registers. A function declared as a string must leave SP pointing to the first byte of the result, in this case, the length of the string. To accomplish this, the form RET *n* is used, which increases SP by *n* bytes after it POPs the return address. Here, four bytes are present between the return address and the length of the output string—hence the RET 4 instruction. The ORG 100H is left out, indicating that it is not written according to the strict definition of a .COM file. Nevertheless, the subroutine is code-segment relocatable and can be linked to Turbo Pascal.

Example three (figure 5). This procedure, which adds an element to a set, illustrates the passing of an enumerated

FIGURE 3: *Reversing a STRING*

TURBO PASCAL PROGRAM

```
PROGRAM PROC_EXAMPLE(INPUT,OUTPUT);
TYPE  STR = STRING[3];
VAR   ST1,ST2:STR;

PROCEDURE OUT1(ST3:STR; VAR ST4:STR); EXTERNAL 'SUB.COM';

BEGIN
  READLN(ST1,ST2);
  OUT1(ST1,ST2);
  WRITELN(ST2)
END.
```

ASSEMBLY LANGUAGE PROCEDURE

```
CSEG     SEGMENT
   ASSUME   CS:CSEG
   ORG      100h
START:
   PUSH     DS
   PUSH     SS
   PUSH     BP
   PUSH     BX
   PUSH     AX
   MOV      BP,SP             ;1
   MOV      AX,[BP+14]        ;2
   MOV      DS,AX             ;3
   MOV      BX,[BP+12]        ;4
   MOV      BYTE PTR [BX],3   ;5
   MOV      AL,[BP+19]        ;6
   MOV      [BX+1],AL         ;7
   MOV      AL,[BP+18]        ;8
   MOV      [BX+2],AL         ;9
   MOV      AL,[BP+17]        ;10
   MOV      [BX+3],AL         ;11
   POP      AX
   POP      BX
   POP      BP
   POP      SS
   POP      DS
   RET
CSEG     ENDS
   END      START
```

STACK ORGANIZATION

BP + 19	ST3 CHAR 3	
+ 18	ST3 CHAR 2	
+ 17	ST3 CHAR 1	
+ 16	ST3 LENGTH	
+ 14	ST4 SEGMENT	
+ 12	ST4 OFFSET	
+ 10	RETURN ADDRESS	
+ 8	SAVED DS	
+ 6	SAVED SS	
+ 4	SAVED BP	
+ 2	SAVED BX	
BP + 0	SAVED AX	← SP

Here, the first three characters of ST3 are reversed and placed in ST4. ST4 must be a VAR so it can be modified.

UNIX TOOLS FOR YOUR PC

FIGURE 4: *Function Returning a STRING*

TURBO PASCAL PROGRAM

```
PROGRAM FUNCTION_EXAMPLE(INPUT,OUTPUT);
TYPE  STR = STRING[3];
VAR   ST1,ST2:STR;

FUNCTION F(ST3:STR):STR; EXTERNAL 'SUB.COM';

BEGIN
  READLN(ST1);
  ST2 := F(ST1);
  WRITELN(ST2)
END.
```

ASSEMBLY LANGUAGE FUNCTION

```
CSEG     SEGMENT
 ASSUME    CS:CSEG
START:
 PUSH      DS
 PUSH      SS
 PUSH      BP
 PUSH      AX
 MOV       BP,SP
 MOV       BYTE PTR [BP+14],3     ;LENGTH OF OUTPUT STRING IS 3
 MOV       AL,BYTE PTR [BP+11]    ;FIRST CHAR OF INPUT TO
 MOV       [BP+17],AL             ;   THIRD CHAR OF OUTPUT
 MOV       AL,BYTE PTR [BP+12]    ;   ............
 MOV       [BP+16],AL             ;   ............
 MOV       AL,BYTE PTR [BP+13]    ;THIRD CHAR OF INPUT TO
 MOV       [BP+15],AL             ;   FIRST CHAR OF OUTPUT
 POP       AX
 POP       BP
 POP       SS
 POP       DS
 RET       4                      ;ADD 4 BYTES TO SP AFTER RET
CSEG     ENDS
 END       START
```

STACK ORGANIZATION

BP + 17	F CHAR 3
+ 16	F CHAR 2
+ 15	F CHAR 1
+ 14	F LENGTH
+ 13	ST3 CHAR 3
+ 12	ST3 CHAR 2
+ 11	ST3 CHAR 1
+ 10	ST3 LENGTH
+ 8	RETURN ADDRESS
+ 6	SAVED DS
+ 4	SAVED SS
+ 2	SAVED BP
BP + 0	SAVED AX ← SP

Here, the four bytes from ST3 are removed from the stack upon exit so that SP points to the function return value.

FIGURE 5: *Using SETs*

TURBO PASCAL PROGRAM

```
PROGRAM SET_EXAMPLE(INPUT,OUTPUT);
TYPE  DAY = (MON, TUE, WED, THU, FRI, SAT, SUN);
      SETDAY = SET OF DAY;

VAR     A,B:DAY;
  X:SETDAY;

PROCEDURE OUT3(V1:DAY; VAR V2:SETDAY); EXTERNAL 'SUB.COM';

BEGIN
   A := WED;
   X := [MON, TUE, THU, FRI];
   OUT3(A,X);
   IF WED IN X
   THEN WRITELN('PROCEDURE WORKS!')
END.
```

ASSEMBLY LANGUAGE PROCEDURE

```
CSEG     SEGMENT
ASSUME     CS:CSEG
PUSH       DS
PUSH       SS
PUSH       BP
PUSH       BX
PUSH       AX
PUSH       CX
MOV        BP,SP
MOV        AX,[BP+16]      ;SEGMENT OF V2
MOV        DS,AX           ;    INTO DS
MOV        BX,[BP+14]      ;OFFSET OF V2 INTO BX
MOV        CL,[BP+18]      ;(1) V1 INTO CL
MOV        AL,1            ;(2) 00000001 INTO AL  4
SHL        AL,CL           ;(3) SHIFT CL TIMES
OR         [BX],AL         ;(4)     THEN USE OR TO ADD V1 TO SET
POP        CX
POP        AX
POP        BX
POP        BP
POP        SS
POP        DS
RET
CSEG     ENDS
END
```

STACK ORGANIZATION

BP + 18	V1
+ 16	V2 SEGMENT
+ 14	V2 OFFSET
+ 12	RETURN ADDRESS
+ 10	SAVED DS
+ 8	SAVED SS
+ 6	SAVED BP
+ 4	SAVED BX
+ 2	SAVED AX
BP + 0	SAVED CX ← SP

All 32 bytes of a set are passed on the stack; the word at [BP + 14] holds the first 16 members (0 through 15).

type as input (V1) and a set type as output (V2). The value of V1 that is passed as input (WED) has an ordinal value of 2. Also, the set V2 occupies only one byte (it has only seven elements and is not a value parameter). Thus, to add V1 to V2, the routine simply sets bit 2 in the byte V2 (lines 1 through 4 do just that). In this subroutine, the START labels have been eliminated; EXE2BIN still converts it as required.

OTHER COMPONENTS

The techniques described above can be extended to allow local variables. The *local work area* is a place on the stack that cannot be overwritten by a PUSH or a POP. This area can be created with a single instruction, preferably executed after SP is saved in BP:

```
SUB   SP,N_BYTES
```

The five bytes between the previous stack top and the new stack top will not be affected by PUSH instructions, which move the stack top to even lower addresses. It is within the work area that an array or record value parameters would be copied for local use. When this area is no longer needed, the stack pointer should be returned to its position prior to the area's creation. This return can be accomplished by adding N_BYTES to SP, moving BP into SP, or specifying an appropriate value of *n* in the RET instruction.

Multiple subroutines can be used to code several subroutines into one executable file. A slight modification is made to the procedure (or function) heading for all subroutines except the first. If the procedures SUB1, SUB2, and SUB3 are stored in the file SUBS.COM, a declaration might look like this:

```
PROCEDURE SUB1( parameters);
  EXTERNAL 'SUBS.COM';
PROCEDURE SUB2( parameters);
  EXTERNAL SUB1[3];
PROCEDURE SUB3( parameters);
  EXTERNAL SUB1[6];
```

In the SUB2 and SUB3 declarations, the number inside the brackets is an offset (in bytes) from the start of SUBS.COM. When Pascal calls SUB3, it enters the file SUBS.COM at a point six bytes from the beginning. It easily can be arranged for this location to transfer to the first line of SUB3. The standard method is to begin SUBS.COM with a jump table:

```
JMP   SUB1
JMP   SUB2
JMP   SUB3
```

The advantage of using a jump table, rather than specifying the offset of the SUB3 routine in SUBS.COM, is that changes can be made to the code in SUBS.COM without the need to change the declaration to correct the offset.

More in-depth study of any of the routines presented here should involve DEBUG. The user would make the first executable instruction in a subroutine an INT 1, then load the Turbo Pascal-compiled .COM file under DEBUG and run it with the Go command. DEBUG will stop at INT 1 and permit single-stepping from there. This kind of examination would enable the user to view memory, the stack, and the registers.

Turbo Pascal's facilities for externally linking to a .COM file provide a clean, elegant method for linking external assembly language routines into a Pascal program. Other common methods, such as using INLINE, are clumsy in comparison. Once the intricacies of Turbo Pascal's parameter passing and data representation are mastered, applications can be written to balance the speed of assembly language with the structure of Turbo.

Richard Halpern is an assistant professor of computer science at the State University of New York (SUNY) at New Paltz, New York. He is the author of Microcomputer Graphics Using Pascal *(Harper & Row, 1985).*

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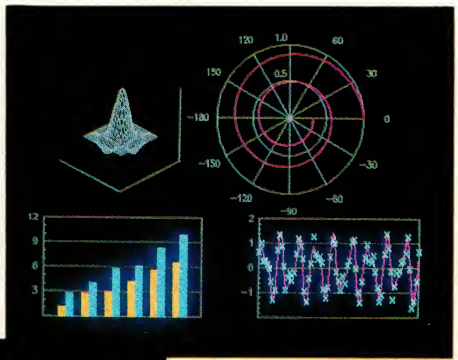

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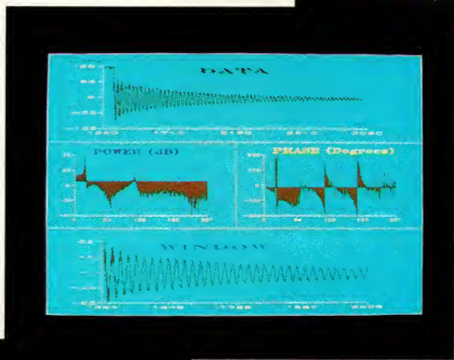

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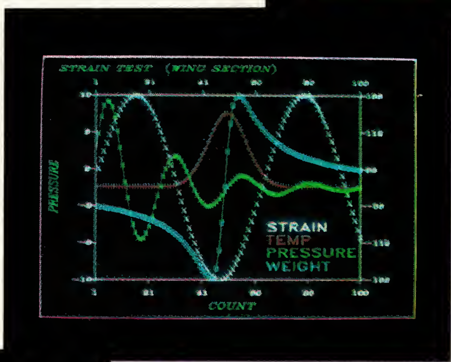

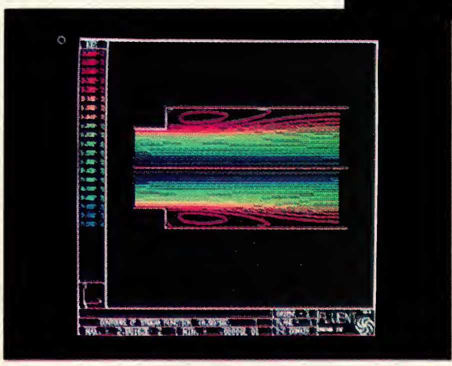

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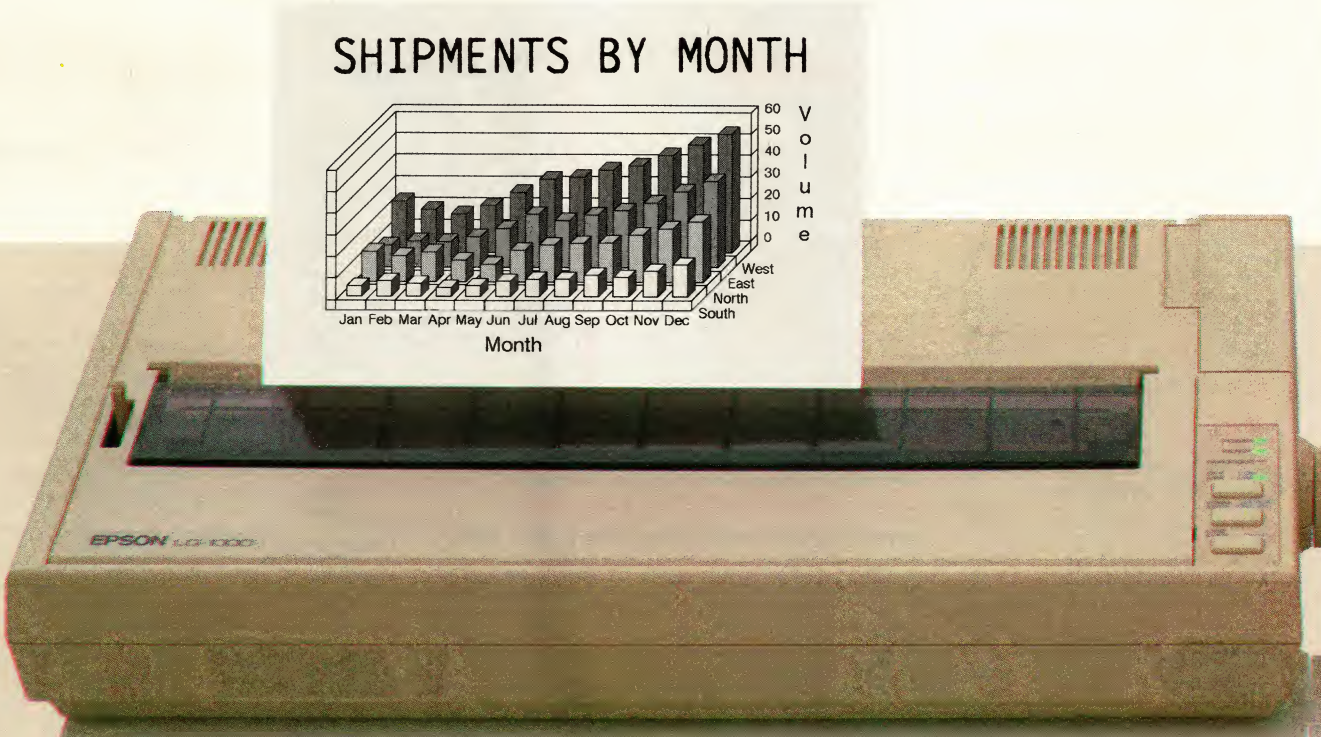
with source	1500	1185
dbVista *single user DBMS by Raima*	195	139
dbVista *multi-user DBMS*	495	399
Opt-Tech Sort *Can sort Btrieve files*	149	105
SCREEN DESIGN		
Curses *by Lattice, UNIX screen designer*	125	99
with Source	250	199
Greenleaf Data Windows......*New*	225	169
with source	395	297
source purchased later	225	169
On-Line Help *from Opt-Tech Data*	149	105

	LIST	US
Panel *by Roundhill, no royalties*	295	229
View Manager for C *by Blaise*	275	164
Vitamin C *by Creative Programming*	225	198
VC Screen *by Creative Programming*	100	81
Windows for C *Vermont Creative Software*	195	149
Windows for Data *includes Windows for C*	295	259
ZView *Data Management Consultants*	245	175
GRAPHICS		
Essential Graphics *by Essential, no royalties*	250	210
GSS Graphics Development Toolkit	495	375
GSS Kernel System *by Graphic Software*	495	375
GSS Metafile Interpreter	295	235
GSS Plotting System	495	375
Halo *by Media Cybernetics*	300	219
with **Dr. Halo II**	440	299
Halo for Microsoft *includes all fonts*	595	434
COMMUNICATIONS		
Asynch Manager *by Blaise, for C or Pascal*	175	117
Greenleaf Communications *by Greenleaf*	185	139
PTel *by Phoenix, Binary File Communicator*	195	115
UTILITY LIBRARIES		
Blaise C Tools Plus	175	117
Blaise C Tools	125	84
Blaise C Tools 2	100	67
C Food Smorgasbord *by Lattice*	150	109
C Utility Library *by Essential, 300 functions*	185	139
Greenleaf Functions *by Greenleaf Software*	185	139
PforCe *by Phoenix, vast library*	395	235
Software Horizons *Packages*	Var	Call
TopView Tool Basket *by Lattice, source avail*	250	199
DEVELOPMENT TOOLS		
Code Sifter *by David Smith Software, Profiler*	119	89
C-Worthy *by Custom Design Software*	295	269
C-Worthy for Network *Menus, help, errors*	495	449
Dan Bricklin's Demo Program *Prototyper*	75	69
LMK from Lattice *by Lattice, "make" like UNIX*	195	149
Microsoft Window Development Toolkit	500	365
PC-Lint *by Gimpel Software, after UNIX's "lint"*	139	125
PFinish *by Phoenix, EXE performance analyzer*	395	235
Plink86 Plus *Utilizes memory for overlays*	495	325
Pmaker *by Phoenix, like UNIX "make"*	125	85
Pre-C *by Phoenix, UNIX "lint"-alike*	295	155
Pfantasy Pac *six Phoenix products*	1295	875
OTHER TOOLS		
BASTOC *by JMI, convert BASIC to C*	495	399
BASIC-C *BASIC's functions added to C*	175	139
The HAMMER *by OES Systems*	195	139
Report Option *by Softcraft, Btrieve Report Gen.*	145	128
Xtrieve *by Softcraft, Query Utility for Btrieve*	245	220
FORTRAN COMPILERS & UTILITIES		
ACS Time Series *by Alpha Computer Service*	495	405
Forlib- Plus *by Alpha Computer Service*	70	45
Microsoft FORTRAN *Links with Microsoft C*	450	281
Microsoft FORTRAN *for XENIX*	695	546
RM/FORTRAN *by Ryan McFarland*	595	Call
Scientific Subroutine Package *by Alpha*	295	239
The Statistician *by Alpha Computer*	295	239
Strings & Things *by Alpha Computer*	70	45
OTHER LANGUAGES & UTILITIES		
Microsoft COBOL Compiler	700	499
Microsoft COBOL Compiler *for XENIX*	995	795
Microsoft COBOL Tools *with Source Debugger*	350	259
Microsoft COBOL Tools *for XENIX*	450	333
Microsoft Lisp *New Common Lisp*	250	189
Microsoft MuMath *includes MuSimp*	300	199
Microsoft Pascal Compiler *Links with M'soft C.*	300	199
Microsoft Pascal Compiler *for XENIX*	695	546
PDisk *Phoenix's new disk manager*	195	125
RM/COBOL *by Ryan-McFarland*	950	Call
RM/COBOL 8X *ANSI 85 COBOL*	1250	Call
Source Print...*source code formatter*	75	60
Tree Diagrammer...*source code diagrammer*	55	45
Help/Control *by MDS...123 style Help*	125	109

OTHERS PALE B



The small printer on the left seems positively unexciting next to the new ALPS ALQ300.

And it's not just because of our colorful personality.

You see, the ALQ300 is a lot faster. It handles bidirectional graphics with flying colors. And for black and white work–spreadsheets, letters, you name it–the ALQ300 zips along as fast as 240 cps.

```
d both offer the same great feature
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ter quality.  They quietly print at
y're versatile.  A full range of mod
ths, transparencies, multiple-part f
les, pitches and fonts.
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The ALQ300 prints everything from the letter quality text you see here, to high resolution graphics in seven colors.

It can do more things. It has snap in/out 24- or 18-pin print heads. Multiple font cartridges. Paper handling extras like automatic single sheet feed and bottom feed. And of course, it runs with all the most popular PCs and software.

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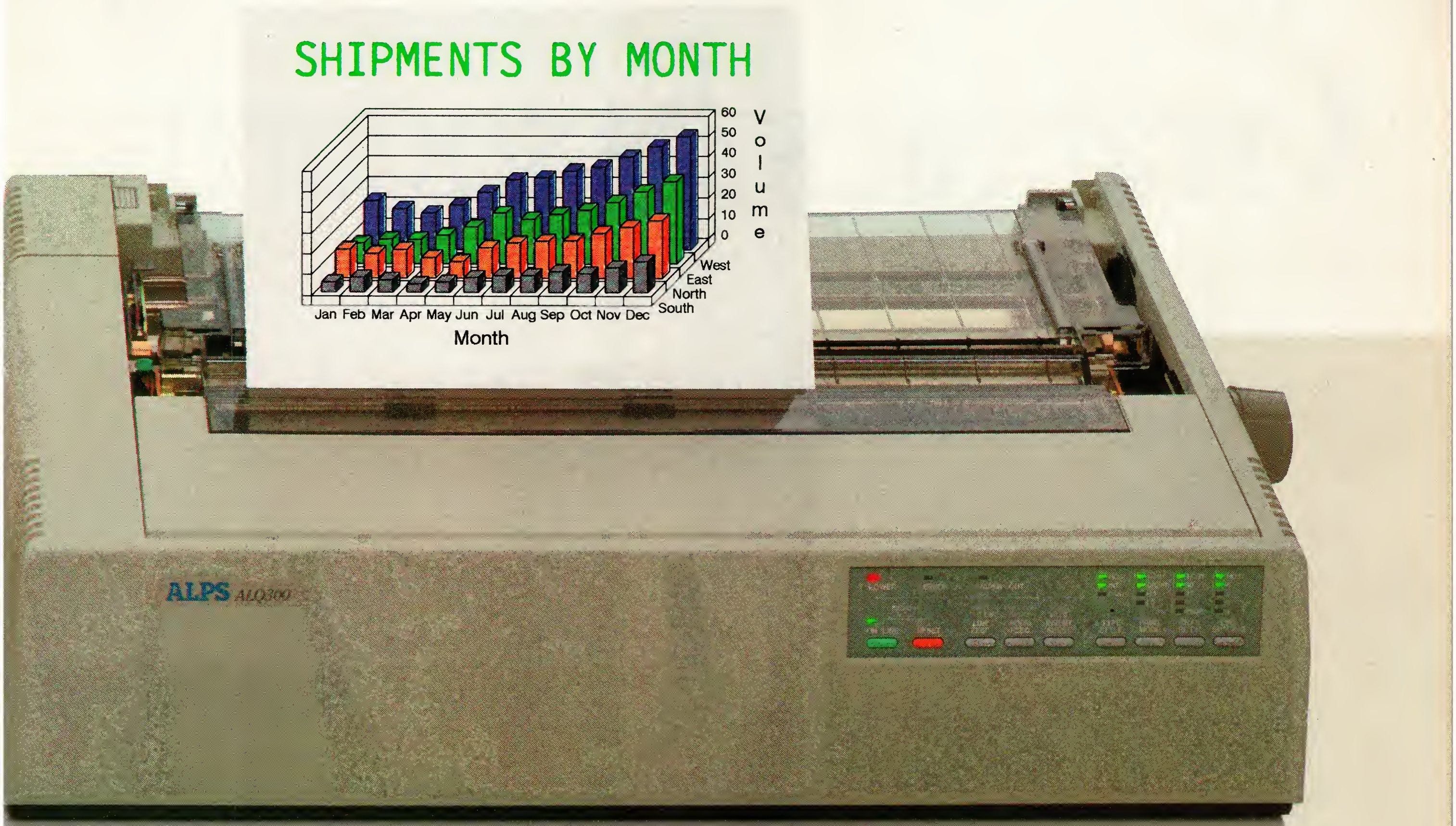

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Synchronizing Graphics Standards

Adaptable-sync monitors answer the needs of today's diverse graphics standards while looking to the future standards.

JOHN C. BLAIR JR.

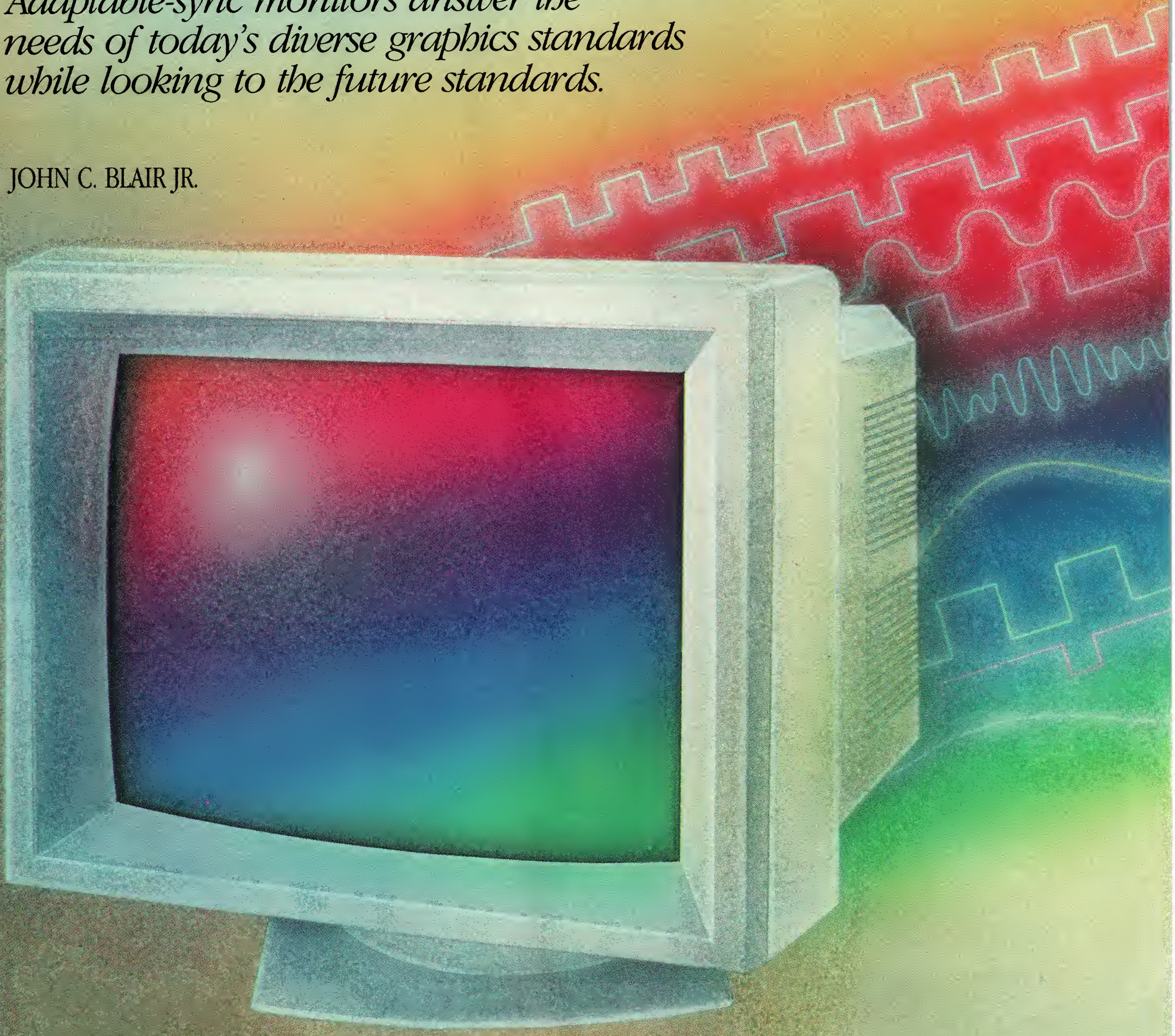


ILLUSTRATION • ANDY LEVINE

In the world of PC computer graphics today, there is no such thing as an unchanging standard, much less an endearing one. The safest claim that a vendor can put forth is that its display is the most versatile one available on the market. Many of the graphics-board manufacturers admit, however, that fixing on a single standard is like trying to freeze the electron beam that flies across the shadowmask of a monitor.

The adaptable-sync monitor provides a partial solution to the elusive PC graphics standard. These monitors not only synchronize with the existing graphics standards—the IBM Monochrome Display and Printer Adapter, Color Graphics Adapter (CGA), Enhanced Graphics Adapter (EGA), and Professional Graphics Controller (PGC)—but they also will be able to accept signals from future graphics boards that exceed the current standards.

Earlier monitors, such as IBM's Monochrome Display and Color Display, were designed to be used only in tandem with their associated display board. The IBM Enhanced Color Display provided the added flexibility of allowing either the CGA or the EGA to be attached. Now, with an adaptable-sync monitor the user can change or upgrade his display system without having to buy a different monitor.

Nippon Electric Corporation (NEC) led the way in the field with its MultiSync monitor, introduced in 1985. Since then several competitors have entered the market. For this article *PC Tech Journal* examined three of them: NEC's MultiSync, Sony Corporation's MultiScan, and Taxan Corporation's 770 monitor (see photo 1). Table 1 compares the specifications of these three monitors with four IBM monitors.

TABLE 1: *Monitor Specifications*

	IBM	IBM	IBM	IBM	NEC	SONY	TAXAN
Product	Monochrome Display	Color Display	Enhanced Color Display	Professional Graphics Display	MultiSync	MultiScan	770
Horizontal sync frequency (KHz)	18.432	15.75	21.8	30	15.5 to 35	15 to 34	15 to 34
Vertical sync frequency (Hz)	50	60	50	60	56 to 62	50 to 100	50 to 90
Max. horizontal pixel resolution	720	640	350	640	800	900	800
Max. vertical pixel res.	350	200	350	480	560	560	600
Shadowmask pitch (mm)	N/A	.43	.31	.31	.31	.26	.31

The adaptable-sync monitors can accommodate the analog signal of the PGC and digital inputs from the TTL display adapters.

EXISTING STANDARDS

The IBM monochrome display adapter has a resolution of 80 characters by 25 rows with each character being 9-by-14 dots. This gives a dot resolution of 720 by 350. The monochrome display accepts a transistor-transistor logic (TTL), digital, horizontal synchronization pulse at 18.432 KHz with a 50-Hz refresh rate. The signals from the display adapter are the vertical sync pulse, the horizontal sync pulse, and the video pulse. The bandwidth of the monitor, the maximum dot frequency it can display, is 16.257 MHz at a –3-decibel level.

The IBM CGA can display 2 colors from a palette of 16 colors at its maximum pixel resolution of 640 by 200. Its display is noninterlaced like the monochrome adapter; RGBI signals are sent as TTL digital signals along with the horizontal and vertical sync pulses. The refresh rate on the CGA is 60 Hz; the horizontal sync frequency is 15.75 KHz. (The CGA was examined in "Graphic Enhancement," Thomas V. Hoffmann, April 1985, p. 58.)

Of much higher resolution is the IBM PGC, an analog board with a display resolution of 640 by 480 that can display 256 colors from a palette of 4,096 (see "Power Graphics," Thomas V. Hoffmann, July 1985, p. 56). The PGC requires a high-resolution analog display, such as the IBM Professional Graphics Display, in which the color signals are sent in analog form and are translated into RGB components within the monitor itself. This means that the monitor cannot be used with any other type of display adapter; however, the PGC does emulate the CGA, thus allowing CGA-compatible software to be run. The Professional Graphics Display has a horizontal scan frequency of 30 KHz with a refresh rate of 60 Hz and a bandwidth of 25 MHz.

Despite its high resolution and more extensive range of colors, the PGC has not gained popularity because of the high cost of the controller and monitor, approximately $4,300. Applications software for the PGC requires a custom device driver to use the facilities of the display system. Many CAD companies have opted to write drivers for slightly more expensive display systems that give resolutions around 1,024 by 1,024. These display systems then can be sold as OEM products.

The more reasonably priced EGA has emerged as the most popular standard for graphics applications, primarily because of its backward compatibility. Existing applications that run on the CGA can function without modification on the EGA, and vendors can upgrade their software to use the EGA.

The IBM EGA has a maximum resolution of 640-by-350 pixels, displaying 16 colors from a palette of 64. This requires a horizontal scan frequency of 21.8 KHz and a refresh rate of 50 Hz. When in this 16-color mode, the signals sent to the monitor are two red, two green, and two blue signals (RGBrgb). These color signals, along with the horizontal and vertical sync pulses, enable a larger range of colors to be obtained than is possible with the CGA.

The current IBM EGA resolution has been superceded by the high-resolution EGA boards, such as Video 7's VEGA Deluxe and Tseng Labs' EVA/480 with a resolution of 640-by-480 pixels. Unfortunately, only a few device drivers are available to take advantage of the full resolution of the TTL display adapters. The technology exists to allow the increase in resolution, but this does not necessarily represent the standard for the future. An increase in resolution is a stepping stone to future standards, not an enduring, solid platform.

PERFORMANCE LIMITS

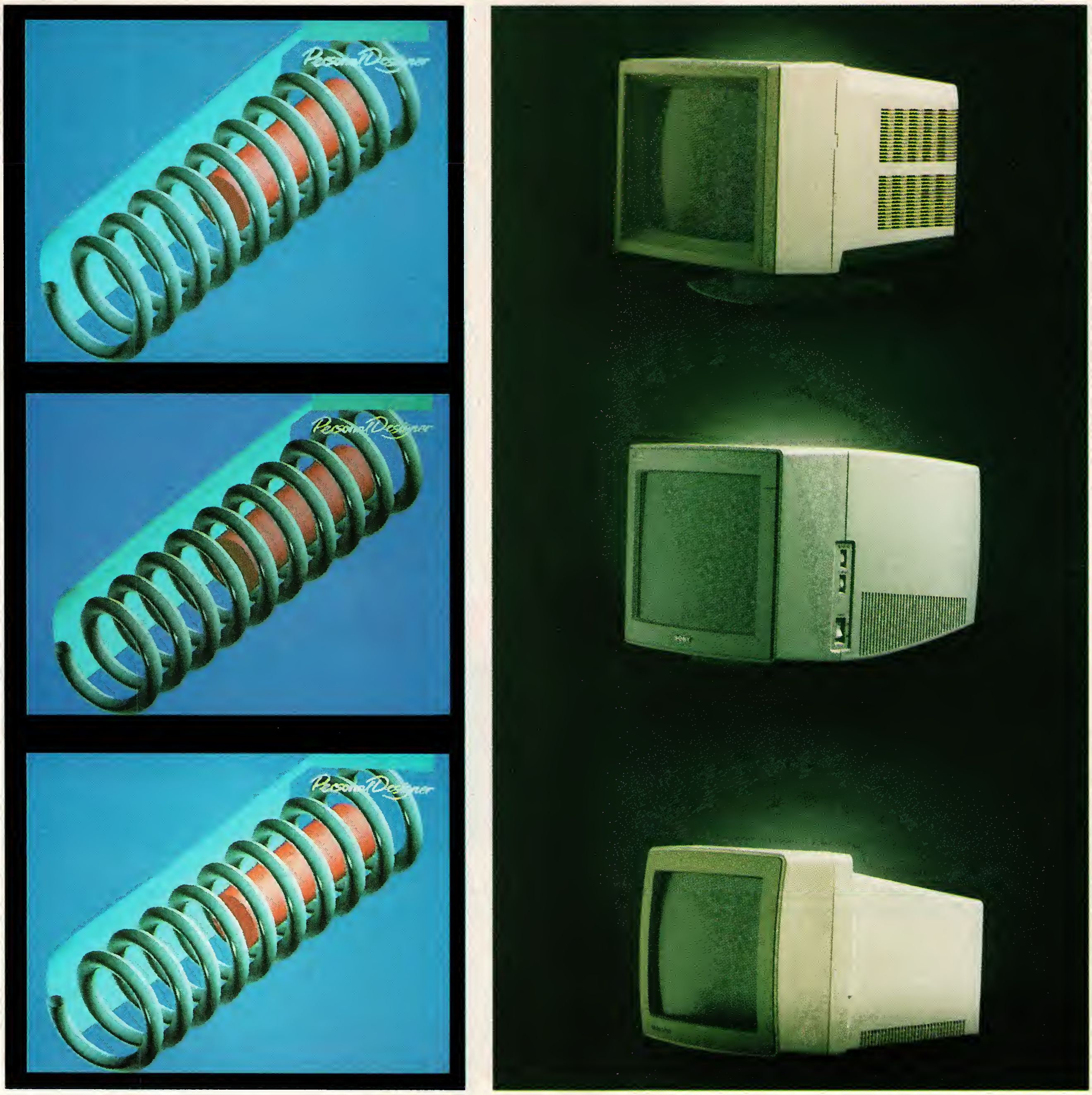
Adaptable-sync monitors have theoretical maximum performances. Using the specifications supplied by the manufacturers provides some insight into the possible life span of these units. As an example, NEC claims its MultiSync can display up to 800 pixels horizontally and 560 vertically; the Sony MultiScan monitor is specified as being able to display up to 900-by-560 pixels; and the Taxan 770 model up to 800-by-600 pixels. This provides room for the standard to grow while still accommodating previous standards, by being able to attach either an analog or a digital display adapter. The new monitors allow users to take advantage of the evolving standards without knowing what the next major standard will be.

The versatility of adaptable-sync monitors can be appreciated by an understanding of their various limiting specifications. A monitor consists of a cathode ray tube (CRT) that has an electron gun in the rear. This gun transmits a beam of electrons from the rear of the tube to the front phosphor-coated screen that is seen by the user. The electron beam is moved from side to side by the deflection coil using the horizontal sync pulse and from top to bottom by the deflection coil using the vertical sync pulse. (This process is described in "Instant Screens," Augie Hansen, June 1986, p. 96.)

With a color display the operation is expanded. A CRT can have either three guns (see figure 1), one each for the red, green, and blue signals, as with the NEC monitor, or it can have one gun, as with the famous Sony Trinitron system (see figure 2).

For a three-gun system a beam of electrons is sent from the rear of the tube from each gun. The beam passes through a shadowmask (a precision-drilled plate with holes) before reaching the screen. Each pixel consists of a triangle of three phosphor dots—one red, one green, and one blue (see photo 2). The size of the pixel is sufficiently small that the human eye is tricked into seeing a color that is a combination of the red, green, and blue components rather than the individual dots themselves. The size of the holes in the shadowmask and the pitch of the

PHOTO 1: *Adaptable-sync Monitors and Screen Comparisons*



Video board and slide for screen shots supplied by ComputerVision

The NEC MultiSync (top right) has a deep bezel compared with the Sony and Taxan models. The MultiSync has an attached stand, while the Sony MultiScan (middle) and Taxan 770 (bottom) have separate stands available. The various monitors show slight differences in color. These differences may depend on the actual set-up of the individual monitor and on ambient light conditions. Screens shown above are from top to bottom, the NEC MultiSync, Sony MultiScan, and Taxan 770.

mask (the distance between adjacent holes) affect the clarity of the pixel.

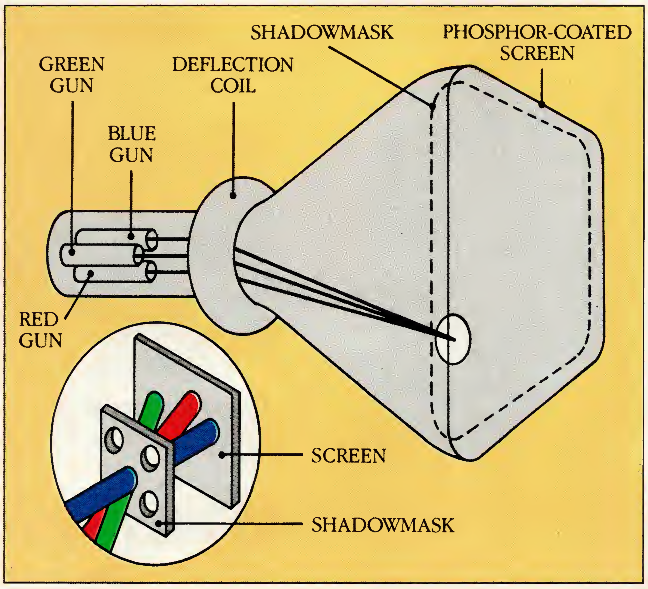
In the single-gun Sony Trinitron system the pixel consists of three strips side by side as the gun transmits three beams of electrons side by side (see photo 3). The equivalent of a shadow-mask for this type of monitor is an aperture grill with vertical slots, rather than circular holes.

The signals from the monochrome display, CGA, EGA, and high-resolution EGA boards are digital. The video signals contain the on/off information about a particular pixel that is to appear on the screen. For the monochrome display, the information is in the video pulse that is transmitted from the adapter to the monitor. In the color displays the red, green, and blue information for each pixel is sent individually. Once it is received by the monitor, this information is converted to analog form and sent to the color guns.

The video signal transmitted from the PGC is analog; it is used more directly by the monitor. Because the display adapter is supplying the color information, the adapter and monitor need to be in tune with each other.

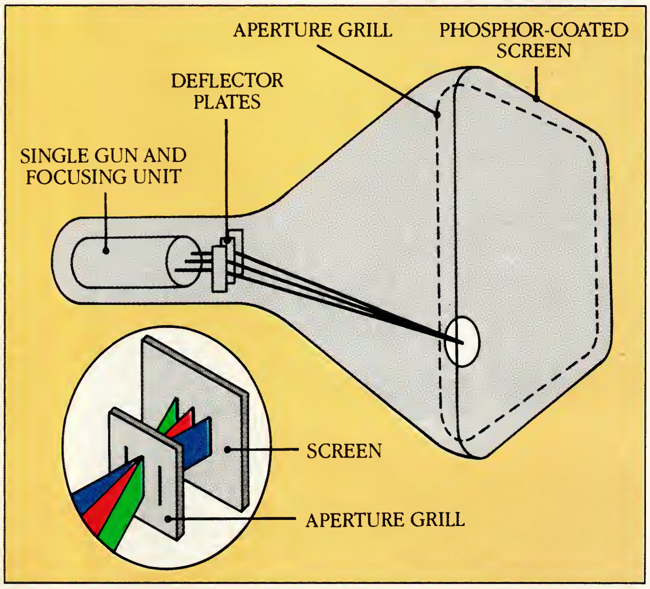
Adaptable-sync monitors do not accept just one type of input. Figure 3 shows a functional block diagram of an adaptable-sync monitor. A switch on the monitor enables the user to select either analog or digital input. The in-

FIGURE 1: *Three-Gun CRT*



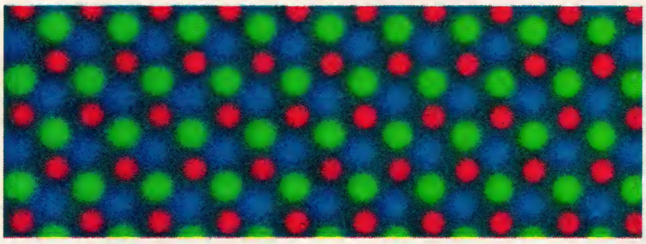
The three guns at the rear of the cathode ray tube emit a beam of electrons toward the front of the tube. They converge at the shadowmask and pass through onto the screen, causing their respective phosphor dots to glow as the pixel.

FIGURE 2: *Single-Gun Color CRT*



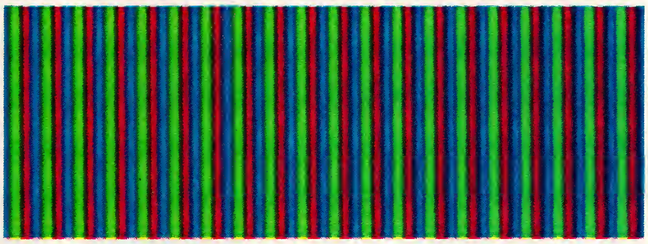
The single-gun assembly within the Sony Trinitron tube emits three beams of electrons side by side that make up the pixel. This design enables the convergence setting to be simpler because the three beams are on a single axis.

PHOTO 2: *Shadowmask*



A triangle of three dots makes up a single pixel. The actual color of the pixel is determined by the brightness of the combination of the three phosphor dots.

PHOTO 3: *Sony Trinitron Mask*



With a Sony aperture grill, the pixel is made up of the three slots side by side. The pitch of the Sony mask is 0.26mm compared with 0.31mm for the NEC and Taxan monitors.

coming signals are synchronized and used to create the display. The horizontal and vertical sync frequencies vary among adapters. Adaptable-sync monitors can accept these variations and produce a satisfactory display with a variety of resolutions and color ranges.

The maximum, horizontal sync frequency limits the number of horizontal lines that can be displayed per second, and the vertical sync frequency affects the refresh rate for the screen. The bandwidth of the monitor is the limiting factor of a display. Its value gives an indication of how many dots per second can be displayed without blurring the image. Blurring results from the color information being fed to the guns faster than the monitor can move to the next hole in the shadowmask. For the PC market the limits for the monitor need to be translated into pixels in order to judge the highest future standard that an adaptable-sync monitor can support. The bandwidth and the maximum horizontal and vertical sync frequencies, including the horizontal and vertical retrace times, are used to calculate the maximum number of pixels that can be displayed on a monitor.

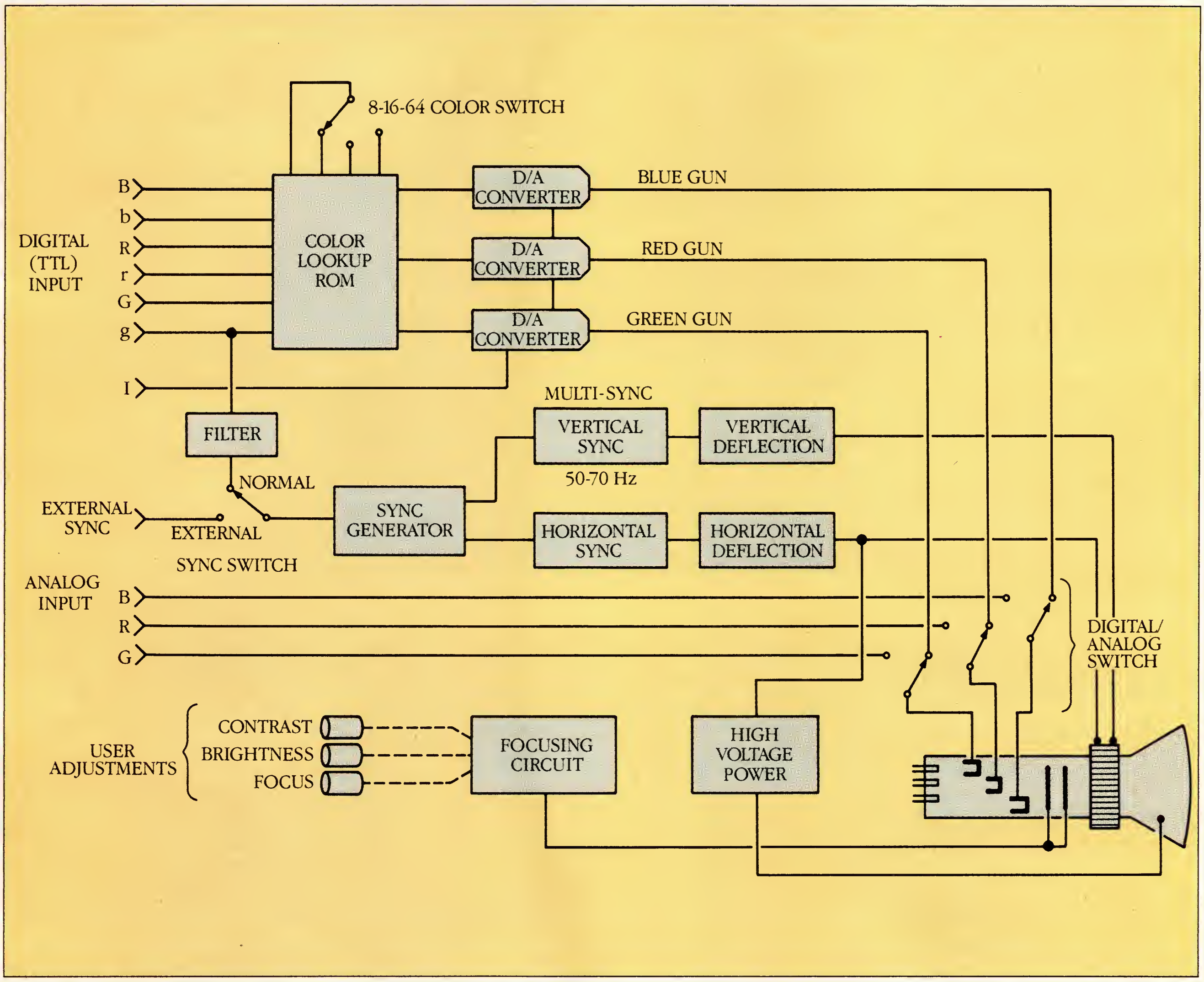
The adaptable-sync monitors on the market translate the horizonal and vertical sync frequency limits into horizontal and vertical pixels; for the Sony MultiScan this is 900 by 560, for the NEC MultiSync, 800 by 560, and for the Taxan 770, 800 by 600. Depending on the future designs of the display-adapter manufacturers, these numbers mean that a new graphics standard can appear on the order of 800 by 600 without requiring a new monitor.

A variety of adaptable-sync monitors is available. They each vary ergonomically and visually with the colors that they produce, but they all have similar functional specifications. The three monitors examined here are major contenders in this emerging market. Their individual descriptions below reveal some of the variations among the units.

The selection of a monitor requires some experimentation before purchase. One consideration should be the monitor's particular environment, including ambient light and glare, which may affect individual requirements. The monitor must be tested with the display adapters that are to be used with it, and the colors produced by the monitor should be examined.

The choice of monitor depends on the individual taste and needs of the end user. For CAD applications the clarity of the colors may be the most important feature to consider. In other applications, such as the use of prepared slide shows, it may be more essential to have colors that are identical to those

FIGURE 3: *Functional Block Diagram*



Adapted from original drawing by William T. Maybew

The analog display adapter has a separate input to the monitor. The monitors cannot be damaged by incorrect switch settings.

seen on an IBM monitor. The color produced on the adaptable-sync monitors varies among the different models (see photo 1). For example, some of the monitors display brown (which is really intense yellow) as a true brown representation as the IBM monitors do, whereas others display it as intense yellow or a mustard color.

The adaptable-sync monitors have several adjustment controls, such as vertical hold, horizontal hold, vertical size, and horizontal size. Not all of these are available on board-specific monitors. For example, the IBM Enhanced Color Display has brightness and contrast controls and two vertical size controls, but no horizontal controls.

The actual size of the display window varies on an adaptable-sync monitor whenever different display adapters are installed. However, the various monitor controls, such as the vertical size and width, can be used to adjust the picture for the particular adapter in use. The amount of adjustment that is necessary depends on the specific monitor design and set-up as it was shipped from the manufacturer.

The three units examined degauss, or demagnetize, the screen during a warm reboot. This feature prevents any color smears caused by residual magnetism that may remain from the previous display. These adaptable-sync monitors are also forgiving; they will tolerate the switches being set incorrectly without causing damage to the unit. This characteristic is different from the earlier, board-specific models.

Additional features may be available on the individual monitors. The NEC MultiSync monitor allows the display of text to be a color that is specified by the monitor instead of by the applications software. The monitors may require separate cables for use with different display adapters. For example, the Sony MultiScan requires a different cable for the PGC than it does for the TTL display-adapter boards.

NEC. The JC-1401P3A MultiSync monitor has a bright display that is outstanding even in environments with harsh lighting. As a matter of fact, it is so bright that turning the brightness and contrast controls down all the way does not completely black out the display.

The screen is moderately recessed from the bezel, giving some slight protection against stray outside light. Reflections are fairly easy to see and may be distracting to the user.

The monitor's power switch is located on the rear panel. This is an inconvenient arrangement unless the monitor is plugged into the system unit and the power can be turned on and off from there.

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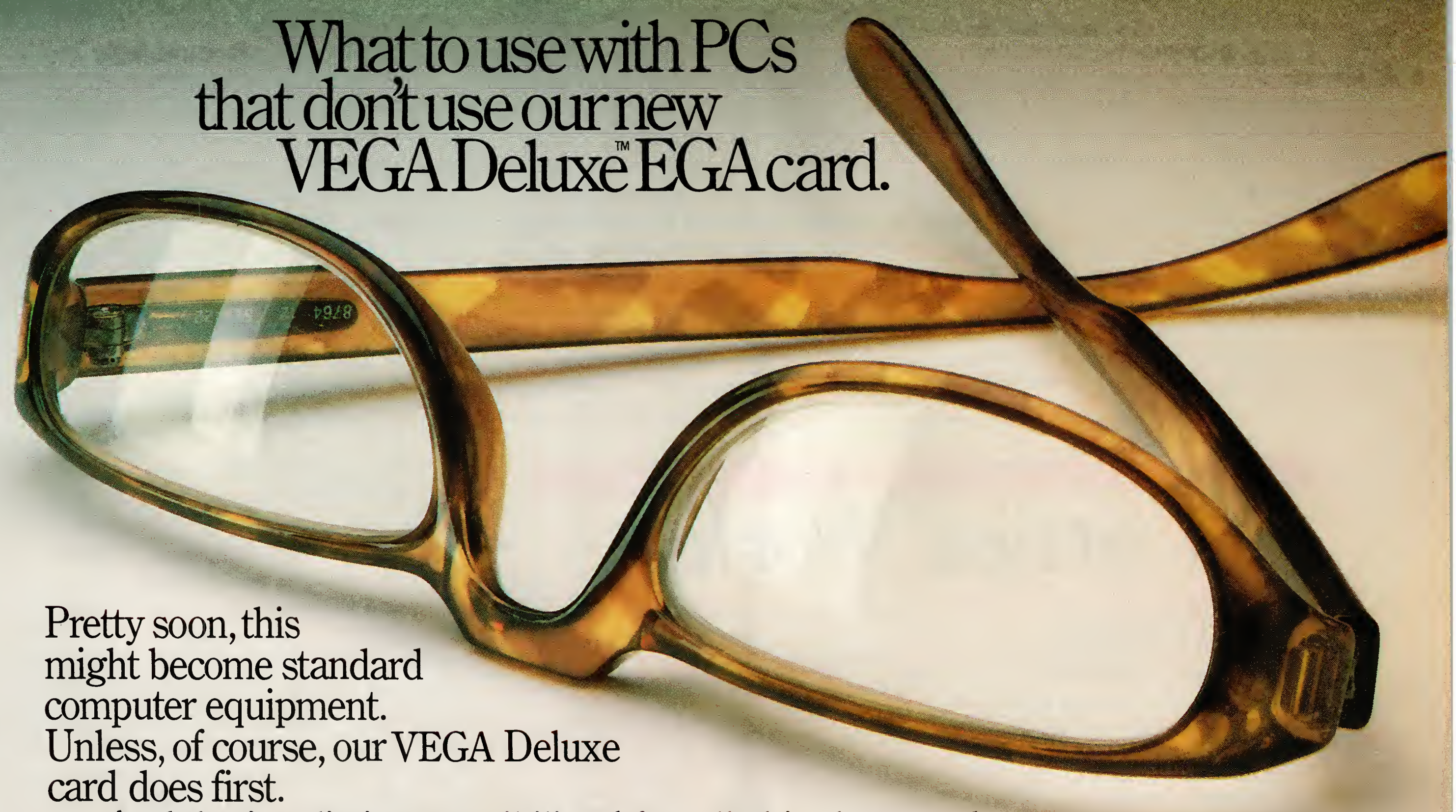

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All of the fine-tuning controls—contrast, brightness, horizontal width, vertical size, horizontal position, vertical position, and text color—are thin shafts arranged in two rows under a small lift-up panel on top. In addition, the MultiSync is the only one of the three monitors described here that has an external vertical-hold control; the MultiScan has automatic vertical control via an internal circuit-controlled oscillator (CCO).

A text switch, also located in the control panel on the top of the monitor, switches the display between a text-only mode and the EGA/PGC mode. If the text-only mode is selected, the display can be forced to show text in the color selected on the rear of the monitor regardless of the settings within the application being used. Text color is determined by selecting the preferred combination of three DIP switches on the back. Eight color combinations, including black on black, are available.

Out of four MultiSync monitors received, two of them had to be returned to NEC to make adjustments to the white balance. When the unit is adjusted optimally, however, the colors and white balance are excellent.

Three LEDs next to the control panel are labeled *manual*, *TTL*, and *power*. The TTL LED is always on, unless the switch on the back is set to analog. The manual LED and switch are for generating non-IBM graphics adapter signals. The primary use of the manual switch is for testing by technicians.

The inside of the NEC unit is more cluttered than that of the Sony MultiScan or the Taxan 770. For example, to change a fuse in the MultiSync, the user must remove the cover and loosen several of the circuit boards.

The MultiSync comes with a tilt-and-swivel stand. The quality of the stand is serviceable, but not outstanding. It is sometimes difficult to manipulate. Many people, however, will probably adjust it once and then move it only to make minor adjustments.

Sony. The CPD-1302 MultiScan monitor, like Sony's Trinitron television sets, has an excellent display. Color saturation is particularly good; the images appear vivid without being harsh. The Sony aperture grill contributes to this quality. The EGA color palette is reproduced faithfully, without any shifting, bleeding, or convergence problems.

The tube is moderately resistant to reflections and can be used easily in areas where sunlight or table lamps are present. The pitch of the aperture grill on the Sony MultiScan is 0.26mm, giving a noticeably finer resolution than the MultiSync and Taxan 770 shadow-masks, both of which have 0.31mm between their dots.

The CRT of the MultiScan monitor is cylindrical, whereas both the NEC and Taxan monitors use a round tube. The brightness and contrast controls are located up front on the right side, as is the power switch. An LED lights up on the bezel when power is on.

The rear of the MultiScan has controls for vertical shift (position), horizontal shift, vertical size, and horizontal size. In addition, a slide switch selects D2 (EGA mode), D1 (CGA), or Normal (IBM 3270) modes. A separate switch is used for choosing analog or TTL.

The Sony package bundles a tilt-and-swivel stand and digital cable with the unit. The stand is of excellent quality and easily manipulated. Additional cables can be ordered for the MultiScan. For most users, however, the choice is really between an analog SMF-513 or a digital SMF-512.

Taxan. The Taxan 770 has an excellent display that is easy on the eyes. The saturation is enough to make colors

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CIRCLE NO. 110 ON READER SERVICE CARD

realistic, but not garish. JVC Information Products Company, which makes most of the electronic components, including the tube, seems to have tried to strike a happy balance in terms of brightness, contrast, and saturation. Indented positions on both the brightness and contrast thumbwheels make it easy to find the normal setting and then adjust to personal preference.

The display screen is very slightly recessed from the bezel. LEDs for TTL, analog, and power are located on the bezel. The controls for contrast, brightness, horizontal position, and vertical position, in addition to the on/off switch are mounted on the right front side of the 770 monitor.

The back of the Taxan has three push-button switches. For EGA mode, these switches should be left in the auto position. In the manual position, special adjustments that normally are not necessary can be made. Potentiometers, which act as subcontrols, enable adjustment of vertical size, vertical position, horizontal size, and horizontal position. A separate set controls each of the four types of graphics modes: the monochrome display adapter, EGA, CGA, and PGC. These 16 subcontrols are protected against casual tampering with a thick sheet of clear plastic that is screwed down. Taxan is the only manufacturer to furnish separate inputs for TTL and analog. The Taxan power cable includes a ferrite core, supposedly to reduce radio frequency interference.

The Taxan monitor received for evaluation did not include a tilt-and-swivel stand, although one is available.

MEETING FUTURE NEEDS

The introduction of the NEC MultiSync and the flood of competitors that are now marketing similar products indicate the popularity of this new generation of monitors. Adaptable-sync monitors are slightly more expensive than the original board-specific monitors, but they offer a longer life expectancy in terms of the evolving display-adapter standards. The convenience of being able to standardize on one monitor regardless of the rest of the system configuration is a major selling point. (In fact, *PC Tech Journal* has equipped all of its technical editors with adaptable-sync monitors to simplify the continual change of system configurations as software and hardware are evaluated.)

Adaptable-sync monitors provide a good midterm solution for the industry. They are versatile enough to fill all of the existing graphics requirements and still provide some security to users by meeting future needs.

NEC Home Electronics (USA), Inc.
Personal Computer Products Division
1255 Michael Drive
Wood Dale, IL 60191-1094
800/323-1728; 312/860-9500
JC-1401P3A MultiSync: $899
CIRCLE 354 ON READER SERVICE CARD

Sony Corporation of America
1 Sony Drive
Park Ridge, NJ 07656
800/222-7669
CPD-1302 MultiScan: $945
CIRCLE 355 ON READER SERVICE CARD

Taxan Corporation
18005 Cortney Court
City of Industry, CA 91748
818/810-1291
Taxan 770: $945
CIRCLE 356 ON READER SERVICE CARD

John C. Blair Jr. is president of Blair Systems Evaluations located in Munroe Falls, Ohio. He has been evaluating hardware and software products since 1976.

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IBM Token Ring* Network	$2,058	$1,474
3Com 3Server3 System*	$1,942	$1,268
Novell* Server System	$2,119	$1,357

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Editors as Programming Tools

Text editors need specific capabilities to be suitable programming tools. Eight editors that qualify as true program editors are described and evaluated.

MARK L. VAN NAME and WILLIAM B. CATCHINGS

Most programmers spend more time using a text editor than any other piece of software. The text editors favored by different programmers vary widely, in part because there is no objective way to demonstrate which are the best or what makes them the best. Few useful, standard performance measures are available. Instead, many programmers tend to judge text editors by "feel" and "power" and can become fiercely loyal in their support of a particular editor.

While many text editors are available, not all are suitable for use specifically as program editors. In particular, most word processors are unsuitable for program editing primarily because of their penchant for rearranging text and inserting nonprintable formatting characters. Even word processors that provide modes for producing straight text files tend to be expensive and oriented toward nonprogrammers.

Eight editors, considered suitable programming tools, are reviewed here: VEDIT PLUS from CompuView Products, Inc.; PC/VI from Custom Software Systems; the Lattice Screen Editor (LSE) from Lattice, Inc.; Epsilon from Lugaru Software, Ltd.; MIX Editor from MIX Software, Inc.; BRIEF from Solution Systems; Emacs from UniPress Software, Inc.; and Program Editor (PE) from WordPerfect Corporation. Table 1 compares the basic characteristics of these eight editors. (One popular editor, PMATE from Phoenix Technologies, Ltd., is not included because Phoenix will replace it soon with a new, more powerful editor called CMATE, which will be reviewed when it is released.)

ILLUSTRATION • CARY HENRIE

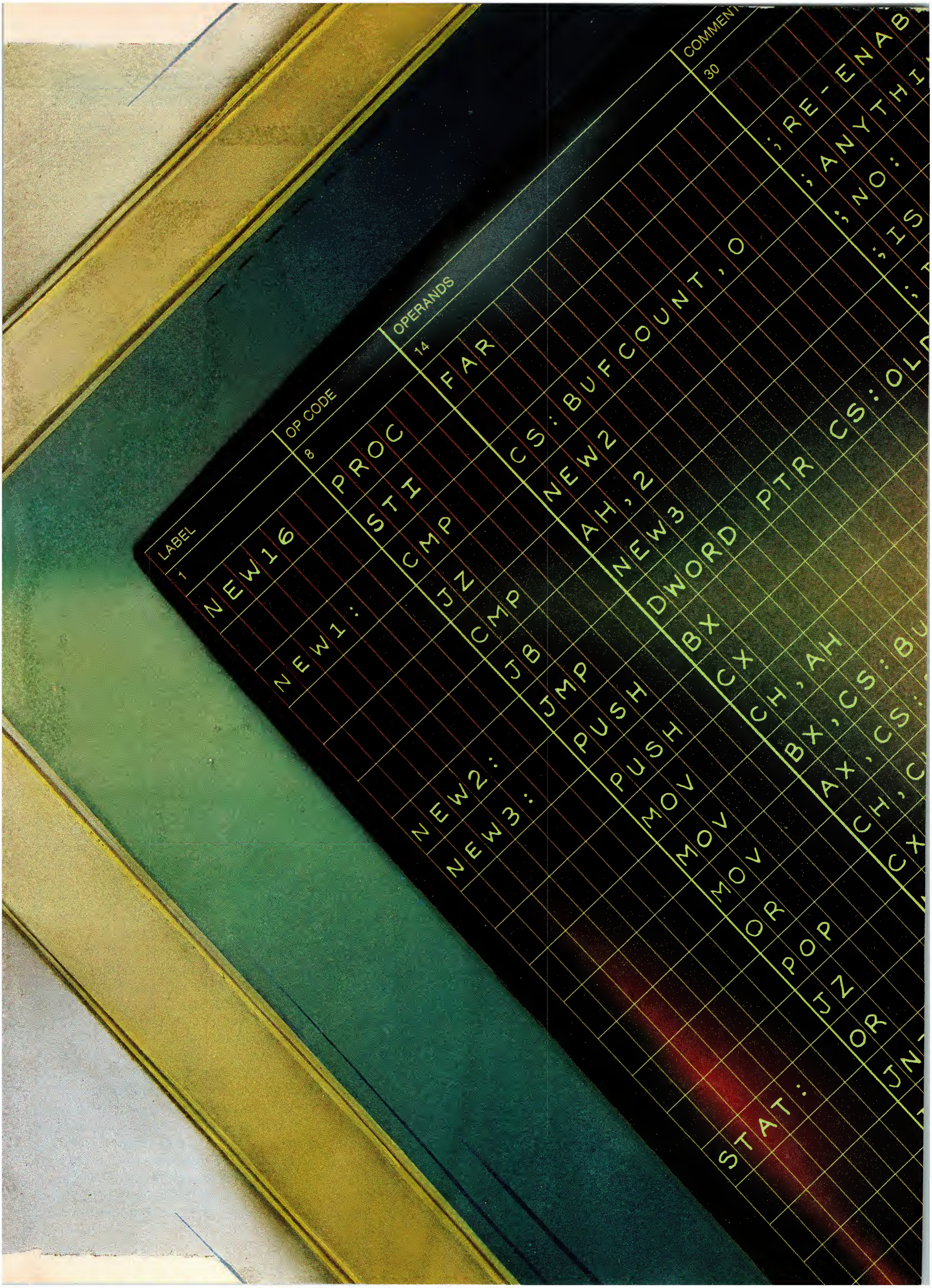
LABEL
1
OP CODE
8
OPERANDS
14
30
NEW16 PROC FAR
STI
CMP CS:BUFCOUNT,0
JZ NEW2
NEW1: CMP AH,2
JB NEW3
NEW2: PUSH BX
NEW3: PUSH CX
MOV CH,AH
STAT:

TABLE 1: *Text Editor Comparison*

	COMPUVIEW	CUSTOM	LATTICE	LUGARU	MIX	SOLUTION	UNIPRESS	WORDPERFECT
PRODUCT	VEDIT PLUS	PC/VI	LSE	Epsilon	Editor	BRIEF	Emacs	Program Editor
VERSION	2.33	1.02	1.00A	3.1x	1.6.0	1.3	1.2	4.1
PRICE	$195.00	$149.00	$125.00	$195.00	$29.95	$195.00	$225.00	$129.00[a]
SYSTEM REQUIREMENTS								
Minimum DOS version	2.0	2.0	2.1	2.0	2.0	2.0	2.0	2.0
Min. memory (KB)	128	192	128	256	192	192	384	80
Rec. memory (KB)	256	256	256[b]	512	256	256	512	256
Main file size (KB)	41	102	66/89[c]	62	64	81	252	51
LIMITS								
File size[d]	Disk	256KB	Memory	Disk	Disk	64,000[e]	Memory	300 pages[f]
Line length (chars.)	1,024	511	256	Unlim.	255	512	64,000	63,000
No. files/windows[g]	Unlim.	1	2	Unlim.	2	Unlim.	Unlim.	2
DOCUMENTATION/HELP								
Total pages	378	139	72	172	103	263	130	106
Table contents (pages)	4	8	5	3	4	12	10	4
Index (pages)	14	0	7	8	3	7	7	6
Reference card	○	●	○	○	○	●	○	○
Key template	○	○	○	○	○	○	○	●
On-line help	●	○	●	●	●	●	●	●
Overall quality	Fair	Fair	Good	Good	Good	Good	Fair	Good

● = *Yes* ○ = *No*

[a] *Available only with the WordPerfect Library.*
[b] *More than 256KB.*
[c] *Two versions, for small and large files, respectively.*
[d] *Disk means that size is limited by disk space for temporary buffers. Memory means that file size is limited to whatever can fit into memory at one time.*
[e] *BRIEF files sizes are limited to 64,000 lines.*
[f] *Program Editor pages may contain up to 65,000 lines.*
[g] *Unlimited means that the number of files is limited only by available memory, the number of windows by physical screen limitations.*

Although all of these text editors perform the same basic tasks, the manner in which they approach these tasks varies widely. Programmers usually select an editor on the basis of what they will be most comfortable with over the long term.

Most programmers expect specific features in their text editors. The capabilities used to determine which text editors qualified as programming tools for this review are listed below.

- It must run under DOS.
- It must be able to input and output straight ASCII text files without inserting nonprintable characters in the text. Ideally, it even should allow a tab to be stored either as spaces or as the tab character.
- It must maintain the user's placement of text on the line it is entered and not automatically wrap words, justify, indent, or perform other manipulations. Those functions are often useful in writing documentation and other nonexecutable text, but if provided, must remain inactive until specifically requested by the programmer.
- It must support macros—that is, some means by which the programmer is able to execute a series of operations by using one command.
- It should support the simultaneous editing of at least two text files, preferably with multiple windows on the screen at the same time. While not an absolute requirement, this ability is particularly useful during development for tasks such as viewing errors generated by a compiler and correcting them in the source code.

A FRAMEWORK FOR JUDGING

The tasks of text editors are to enter and modify source code. The audience is the programmer, a sophisticated microcomputer user. Within this framework, the following criteria were used to review eight editors. (Table 2 compares their editing features.)

Style. Most text editors display a file on the screen, put the cursor on the first character, and let the user enter normal text by typing it. Text editors differ, however, in how to perform various commands, such as line deletion.

The majority of text editors are largely key driven. The programmer issues commands by pressing one or a combination of special-purpose keys, such as function keys, the numeric keypad, and Esc, Ctrl, and Alt. Ctrl and Alt typically are used with other keys. While this approach speeds editing functions, the user must remember a different keystroke combination for each operation. This disadvantage is diminished by use of labels, templates, and command reference cards.

Other editors are command driven: when in text entry mode, the programmer types a key sequence that places the cursor on a command line and then types the name and, if appropriate, arguments of a command. While this approach reduces the number of key sequences that must be memorized, the user still must know the names of the commands. This type of interface also takes more time and keystrokes than a simple keystroke combination.

Menus are frequently used to supplement or even replace the command line in command-driven editors. Once the user reaches the command line or main menu, he can navigate the menus to find the desired command. This approach requires the least memorization but can consume the most time to perform an operation.

Most text editors assume that their audience is willing to memorize keystroke sequences in the interest of efficiency. However, almost all these key-driven editors also provide a command line or a menu system. Some editors, such as PC/VI, make extensive use of both key-driven and command-line modes, but split editing tasks between these modes. Some operations must be

TABLE 2: *Comparison of Editing Features*

	COMPUVIEW	CUSTOM	LATTICE	LUGARU	MIX	SOLUTION	UNIPRESS	WORDPERFECT
PRODUCT	VEDIT	PC/VI	LSE	Epsilon	Editor	BRIEF	Emacs	Program Editor
BASIC COMMAND STRUCTURE								
Key driven	●	●	●	●	●	●	●	●
Command driven	●	●	●	○	●	●	○	○
SEARCH AND REPLACE								
Backwards	○	○	●	●	○	●	●	●
Single replacement	○	●	●	○	●	○	○	●
Replace with prompt	●	○	●	●	●	●	●	●
Case sensitive	○	●	○	●	○	●	●	●
Ignore case	○	●	○	●	○	●	●	●
Wild cards	●	●	●	●	○	●	●	●
Regular expressions	●	●	●	●	○	●	●	○
TEXT DELETION								
Word	●	●	●	●	●	●	●	●
Line	●	●	●	●	●	●	●	○
To end of line	●	●	●	●	●	○	●	●
To end of screen	○	○	○	○	○	○	○	○
BLOCK SUPPORT								
No. of blocks at once	36	36	1/Wind.	Unlim.	1	1	Settable	1
Delete block	●	●	●	●	●	●	●	●
Copy block	●	●	●	●	●	●	●	●
Move block	●	●	●	●	●	●	●	●
Write block	●	●	●	●	●	●	●	●
Merge file	●	●	●	○	●	●	●	●
UNDO OPERATIONS								
Character deletion	○	●	○	○	○	●	●	●
Word deletion	○	●	○	●	●	●	●	●
Line deletion	●	●	●	●	●	●	●	●
Block deletion	●	●	●	●	○	●	●	●
Restore line	●	●	○	○	○	○	○	○
Other operations	○	○	○	○	○	Most	Most	○
Maximum no. undone	1	1	1	Settable	1	300	Settable	3
MACROS								
By key	●	●	○	●	●	●	●	●
By name	○	○	●	●	●	●	●	●
Prompts in macros	○	○	●	●	●	●	●	●

performed by keystrokes, others by switching to command mode and entering commands on a command line. Inadvertently typing text while in the command mode or commands while in the text mode can have unintended results on the file being edited.

This dual-mode command structure is often the result of adding full-screen capability to a formerly line-oriented editor. In earlier line-oriented editors, user input was by default entered as commands, not as text. Key-driven operations are typical of full-screen editors, where character input is by default entered as text, and commands are performed by special-purpose keys.

Text management. The fastest way to manipulate text is to keep it all in memory. However, this limits the user to editing files no larger than the amount of available free memory. To edit files larger than 64KB would require one of the larger memory-addressing models. These memory models often result in larger, slower editor programs. Some products, such as LSE, offer two versions: a faster, smaller version for files up to about 40KB, and a larger, slower one for bigger files. Others limit the size of files that can be edited to a fixed number of bytes or lines.

In order to handle any size file, a text editor must be able to keep part of the file in memory and part on disk in temporary, or swap, files. While several of the text editors reviewed follow this approach, they differ in how they manage the movement of text between memory and disk. Most make it invisible to the user. Some, such as MIX Editor, require the user to manage some or all of this movement. If an editor keeps only part of the file in memory, operations such as global replace often work only on the portion in memory. Of the products reviewed, only MIX Editor limits global operations to the segment currently in memory.

Reliability. One of the most crucial characteristics of a text editor is how reliably it manages major transitions and error conditions: it must handle errors such as "out of memory" and "out of disk space" without losing any text and must provide convenient and/or automatic backups. All eight of the text editors reviewed are reliable, providing automatic backups and adequate error handling capabilities. They all require confirmation if the user attempts to exit before saving changes; however, VEDIT PLUS, LSE, MIX Editor, and PE require

	COMPUVIEW	CUSTOM	LATTICE	LUGARU	MIX	SOLUTION	UNIPRESS	WORDPERFECT
MACROS *(continued)*								
Store in files	●	○	●	●	●	●	●	●
ASCII format	●	●	●	●	●	●	●	○
KB macros at once	Unlim.	36	10[a]	Unlim.	Unlim.	1	Unlim.	26
TABBING								
Default storage	Tabs	Tabs	Tabs	Tabs	Tabs	Tabs	Tabs	Tabs
Store as blanks	●	○	○	●	●	○	●	●
Set irregular intervals	●	○	●	●	●	●	●	●
Convert tabs/blanks	○	○	○	●	●	○	●	○
WORD PROCESSING								
Word wrap	●	●	●	●	○	○	●	○
Center	○	○	○	●	●	●	●	○
Page breaks	○	○	○	○	○	○	○	●
Set margins	●	●	○	●	○	○	●	○
Change case	○	○	●	●	●	○	●	●
BACKUPS								
Save backup copy	●	○	●	○	●	●	●	●
Disable backup copy	○	N/A	○	N/A	○	●	●	●
Timed auto backup	○	○	○	●	○	●	●	●
Disable auto backup	N/A	N/A	N/A	●	N/A	●	●	●
Warn of unsaved changes	○	●	○	●	○	●	●	○
PROGRAMMING SUPPORT								
Indent	●	●	○	●	●	●	●	●
Line numbering	○	○	○	○	●	○	○	○
Find compiler error	○	○	●	●	●[b]	●	●	○
SYSTEM INTERFACE								
Shell to DOS	●	●	●	●	●	●	●	●
List directory	●	○	○	●	●	○	●	●
Delete file	●	○	○	●	●	○	●	●
Rename file	○	○	○	○	○	○	○	●
Copy file	○	○	○	○	○	○	○	●
Print edited file	●	○	●	○	●	●	○	●

● = Yes ○ = No N/A = Not applicable

[a] Any number of macros can be on file; a maximum of 10 can be loaded at once.
[b] MIX C compiler only.

All of the text editors provide the same basic functions of text entry, cursor control, and saving of files. They are distinguished from each other by the quality and kinds of extra features that are provided in addition to the basic ones.

the identical confirmation even when leaving unchanged files.

Ease of use. Along with the command mode, ease of use contributes to the "feel" by which an editor is judged. One important aspect is the reasonable use of the labeled keys on the keyboard. If keys such as Del and PgUp do not cause the expected results, then the editor is working against the user's intuition. Most of the editors reviewed do make reasonable use of the PC's labeled keys. Most also allow the user to change the functions assigned to these keys.

A second aspect in ease of use is compatibility with another editor familiar to the user. Many programmers work in multiple-system environments, such as DOS and UNIX. When a programmer switches between two or more such worlds, the ability to use the same or similar editing commands saves time and energy.

Seven of the program editors reviewed are compatible, to varying degrees, with versions available in other environments; only BRIEF is specific to the PC. VEDIT PLUS is available for several different microcomputers that run the CP/M operating system. PC/VI is an implementation of the UNIX-based text editor, vi. LSE is used in computers other than PC compatibles. MIX Editor has a command structure similar to that of MicroPro's WordStar. Both Epsilon and UniPress Emacs are PC versions of the mainframe EMACS editor, and PE commands are compatible with WordPerfect's word-processing program.

Ease of use in general and compatibility in particular can be enhanced if the user can change the editor's default command-to-key mappings. This capability allows the skilled user to remedy any awkward use of the function or cursor-control keys or to tailor the command structure to resemble another editor or word processor. Six of the editors reviewed offer this useful capability; only PC/VI and PE do not.

Documentation. The documentation should explain the underlying design concept of an editor as well as instruct the user in the editor's operation. The manuals of these eight editors tend to be dry and to contain few examples. They differ widely, however, in the quality of such important aids as an index. Surprisingly few of the editors come with either keyboard templates or command reference cards; they rely instead on a combination of on-line help and the manual.

Power. All text editors provide the same basic services, but the quality and kinds of options vary widely. A powerful editor provides far more than the simple text insertion and deletion operations that are common to all editors.

Many editors differ in the power of their text search-and-replacement functions. All of the editors reviewed here provide the basic functions for locating and replacing simple text strings. However, all but MIX Editor go further, offering some type of pattern-matching capabilities. The simplest pattern matching involves single wild-card characters, such as the * and ? allowed in DOS file names. More complex patterns can be formed using such mechanisms as the regular-expression syntax available on UNIX systems. Regular expressions are combinations of assorted special and wild-card characters used to perform sophisticated searches. For a more detailed explanation and some examples of regular expressions, see the sidebar that accompanies this article.

Text editors also differ in how they address some areas that at first glance seem extremely simple, for example, the use of tab stops. Epsilon and PC/VI restrict tab stops to regular intervals; all the others allow the user to position irregular tab stops. Some store tabs as blanks; others store tabs as the tab character (see table 1). Epsilon, MIX Editor, and UniPress Emacs can convert tabs to either spaces or tab characters, as desired, while PC/VI, LSE, and BRIEF store tabs only as tab characters. VEDIT PLUS and PE take a middle ground: tabs entered by the user can be stored as either spaces or tab characters, but this option does not affect the tabs that are already in the text.

The ability to edit at least two files simultaneously is provided by all of the text editors reviewed, with the exception of PC/VI. LSE, MIX Editor, and PE can handle only two files at once, whereas VEDIT PLUS, Epsilon, BRIEF, and UniPress Emacs are limited only by

REGULAR EXPRESSIONS: THE WILD-CARD ZOO

The two wild-card characters used in DOS file names are two small examples of a large set of string-searching operators known as *regular expressions.* Widely available in the text editors used in UNIX environments, these regular expressions provide a powerful shorthand for representing generalized descriptions of character strings. Basically, regular expressions use special characters—for example, the * and ? of DOS—to represent particular search and replace patterns. The following set is used to write regular expressions in the BRIEF editor.

? Matches any single character, as in DOS file names.

* Matches any string of characters on one line. However, unlike DOS file names, this symbol need not be the last character in an expression. For example, ABC*XYZ will find ABC followed by XYZ on the same line, separated by any intervening text.

{ } Encloses a subexpression. Usage parallels that of parentheses in mathematical expressions.

@ Matches any number of occurrences of the preceding character or subexpression. X@ matches a string of any number of Xs, and {123}@ matches 123, 123123, 123123123, etc.

| Matches either the preceding or following character or subexpression. For example, H|hello matches either Hello or hello, while {HELLO}|{HI} matches either HELLO or HI.

[ ] Matches any *one* of the characters or expressions that are between the brackets. For example, [ABC] matches A, B, or C.

[a-b] Matches any one character in the range—in this example, a through b. [A-Z] matches any uppercase letter, whereas [0-9] matches any single digit.

[~] Matches any character that is not present within the brackets. For example, [~ABC] matches any character except A, B, and C; [~a-z] matches any character that is not a lowercase letter.

\ Escape character. Characters with special meanings are treated as normal characters when preceded by the escape character. For example, \? matches a question mark and \\ matches a backslash. If the following character has no special meaning, the backslash is treated literally.

\n Matches the sequence of carriage return and line feed. In search strings, this symbol must be last. In replacement strings, it may be followed by other characters or subexpressions.

\t Matches a tab character.

< Matches the beginning of a line.

> Matches the end of a line, but not the new-line sequence. See below for examples of this.

\c Causes the cursor to be placed under the text that matches the character or subexpression following the \c. ABC\cXYZ finds the string ABCXYZ and places the cursor under the X. If \c does not appear, the cursor is placed under the first character of the matched string.

\# In this expression, # is a digit 0 through 9. Represents the text matched by the *#th* subexpression. For example, {[A-Z]} @\0 finds occurrences of repeated uppercase words separated by any number of blanks.

The power of regular expressions is useful not only when searching for text, but especially when replacing a matched string. The distinction between the end-of-line characters > and \n is important for replacement, as shown in the following examples. Suppose a file contains the lines:

Line XYZ ends with XYZ
Line 2 follows

Replacing XYZ> with ABC results in:

Line XYZ ends with ABC
Line 2 follows

The string matched by XYZ> does not include a new-line character, so the new line is not replaced.

Replacing XYZ\n with ABC, however results in the following:

Line XYZ ends with ABCLine 2 follows.

Here, the new line is part of the string being replaced; lack of a new line in the replacement causes the concatenation of the two lines.

Another major feature in replacements is the assignment-operator number. If it is in the replacement string, its value will be the corresponding expression from the matched string. Replacing {Hi}|{Hello} {mom}|{pop} with Greetings \1 leaves the original mom or pop in the string.

Writing useful regular expressions is an arcane art that improves with practice. Once mastered, the skill can aid in many programming and general text processing tasks.

—*Ted Mirecki*

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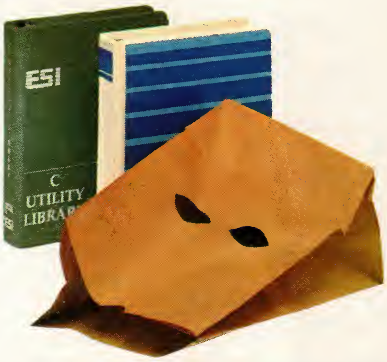

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Essential Software, Inc.

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TABLE 3: *Editor Performance*

	COMPUVIEW	CUSTOM	LATTICE	LUGARU	MIX	SOLUTION	UNIPRESS	WORDPERFECT
PRODUCT	VEDIT PLUS	PC/VI	LSE	Epsilon	Editor	BRIEF	Emacs	Program Editor
LOAD EDITOR AND FILE								
50KB	1.5	5.5	8.0	2.5	4.5	3.0	10.0	2.0
150KB	2.0	25.5	18.0	3.5	7.0	3.5	13.0	5.5
SEARCH FILE (no-find)								
50KB	0.5	1.5	3.5	0.5	3.5	2.5	6.5	2.5
150KB	6.5	6.0	10.0	2.0	9.5	8.0	18.0	9.0
MERGE IN 10KB								
50KB	2.5	7.5	1.5	0.5[a]	0.5	7.0	1.0	0.5
150KB	4.0	8.5	1.5	0.5[a]	1.0	16.0	1.0[b]	1.0
WRITE CHANGED FILE								
50KB	2.0	5.5	7.0	1.5	4.0	5.5	4.0	1.5
150KB	6.0	20.0	17.5	3.5	10.0	14.5	8.5	3.0

Time in seconds, reported to nearest half second.
[a] Function not available, implemented with a macro.
[b] Could not merge file larger than 5KB.

Tests were run on an 8-MHz PC/AT with a standard 30MB hard-disk drive. Timings are the average of at least five runs per test.

available memory or screen space. All of the products that allow multiple file editing are able to display part of both files on the screen at once.

Ease in performing system-level tasks from within the editor also is important. These tasks range from simple procedures, such as file deletion, to more complex jobs, such as compilation. All of these editors provide at least some external function support, usually in the form of a command that invokes a new copy of COMMAND.COM. Upon exiting the shell, the user returns to the text editor. Others work directly with particular compilers, allowing the user to compile code and examine error messages without leaving the editor.

The editors reviewed also differ in the degree to which they can be customized. All provide some customization by means of macros. The number of possible macros and how they are invoked—by name, key, or both—varies. In some, the user's keystrokes define macros. Others provide both that ability and a full macro language, which allows the user, in essence, to write editor command programs.

Performance. These editors in general perform well and do not force the user to wait excessively during normal operations. Table 3 compares their times to perform several operations on large text files of 50KB and 150KB. The most important performance criteria are the times required to load and save files.

EVALUATING EDITORS

The eight text editors are examined in greater detail using all of these criteria. In addition, any unique or unusual capabilities are described.

CompuView Products, Inc. VEDIT PLUS hails from the CP/M world, with both CP/M and MP/M versions as well as the DOS version. It is a powerful, full-featured text editor, with a large command set, support for multiple windows, and a strong macro capability.

VEDIT PLUS has some unusual features not found in the other editors. These include a built-in Z80-to-8086 assembly-code translator and on-line calculator. Two companion products, V-SPELL and V-PRINT (an output formatter), are available for VEDIT PLUS.

The power of VEDIT PLUS is both its major strength and its biggest weakness—it has almost too many com-

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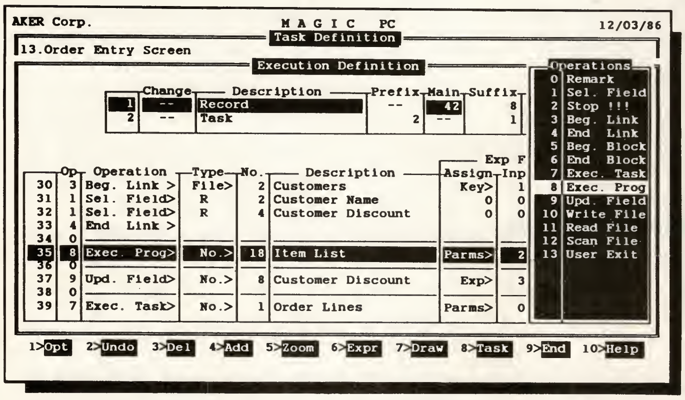

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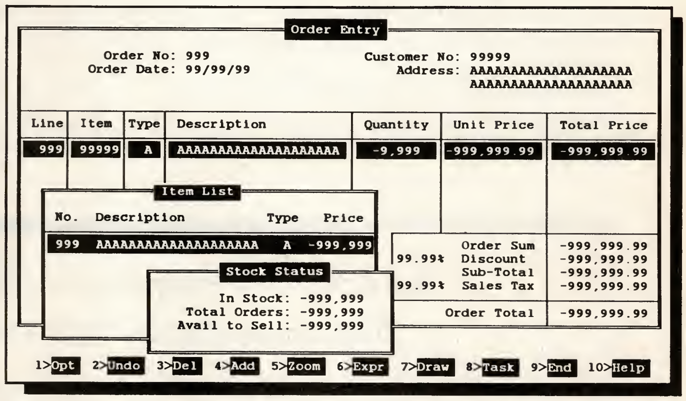

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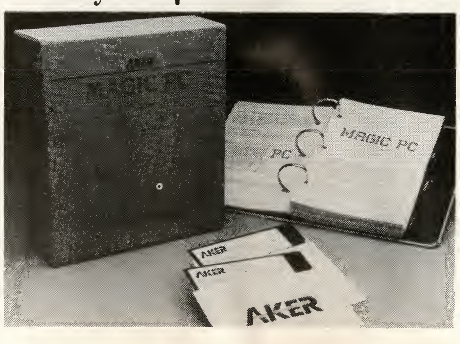

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mands. VEDIT PLUS is both key driven and command driven. It offers two modes of operation: visual and command. In visual mode, the user works directly on the text. In command mode, the user enters both simple commands (also available in visual mode) and more complex commands (available only in command mode).

VEDIT macros consist of strings of commands in the command mode that are stored in one of 36 deletion buffers. Because they are strings, the macros can be edited and stored in a file.

Reflecting its CP/M heritage, VEDIT PLUS is not well integrated with the PC. It uses the numeric keypad in some unusual ways. The arrow keys work as expected, but others often do not. For example, the back-tab command is assigned to the Home key. The user, however, can change these command-to-key mappings, along with a great deal of the editor's behavior, by using a somewhat cumbersome installation program.

VEDIT PLUS performs very well. It manages text by loading files in 64KB chunks and automatically handles saving and loading of the segments. However, search and replace operations are performed only within the currently loaded segment unless global operation is specifically requested. This text editor also lets the user examine DOS directories and delete files.

The documentation is uneven. Concepts often are used before they are explained. Because the manual is oriented toward a number of different systems, it is not well tailored to the PC. Such crucial information as the PC key mappings are in the back and difficult to find. Despite its large number of commands, the manual's command reference section is only 18 pages long, with only one or two lines per command. The manual has more than 378 pages; fortunately, the index is good.

One advantage of VEDIT PLUS is that it runs on a large number of microcomputers that are not PC compatible. Anyone seeking compatibility with CP/M machines and willing to invest the time to understand its features may find this editor to be worthwhile.

Custom Software Systems. PC/VI is a full PC implementation of the UNIX **vi** text editor. UNIX **vi**, based on older, line-oriented editors, also has two modes: command, which contains all of the commands from the earlier line editor, and visual, for full-screen editing.

Visual mode is further divided into two operational styles, or submodes: input and command. Input submode handles the input of normal, visual characters. These characters appear in the onscreen image of the file as the user types them in. Command submode handles certain common editing functions, such as text deletion. These operations are executed by typing normal ASCII character sequences (for example, **dw** to delete a word).

By default PC/VI starts up in command submode. Although the cursor appears in the text, the user is actually entering commands by typing the characters that identify them, such as *i* for insert or *a* for append. Some of these commands may cause the user to enter input submode. Once there, all characters are entered directly into the file. The user returns to command submode by pressing the Esc key. Although the cursor remains where it was in the text buffer on screen, the command line is now activated. The user can type commands to edit the text further. For example, the **dw** command deletes the word in which the cursor is positioned in the text buffer.

These two submodes can be very confusing. The cursor stays in the text

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in both; yet, characters entered while in input submode go into the text, and those entered in command submode act as commands, but are not echoed on the screen. While in command submode any characters that are not recognized as command sequences are simply discarded. Typing a character sequence that is also a PC/VI command while in the command submode can have unexpected results. For example, typing the assembly directive **dw** would delete a word instead of typing the desired assembly code.

This switching between submodes can be hard to master. To complicate matters further, the true command mode (as distinct from the command submode of visual mode) must be considered. The true command mode is reached by entering a colon while in command submode. The cursor then goes to a command line at the bottom of the screen. Some commands, such as those used to read and write files, must be entered from this command line. These three operational styles make PC/VI difficult to learn and use.

In addition, PC/VI has all the other flaws and limitations of UNIX **vi**. It is limited to one file and one window. The user can switch from one file to another, but must write one file before starting another one.

This text editor can be difficult to learn because of its commands, as well. While the commands are somewhat mnemonic, they are very odd. Reflecting its UNIX origin, its commands are case sensitive, and sometimes two commands are mapped to different cases of the same letter. For example, the command **n** finds the next occurrence of a string, while **N** goes to the previous occurrence. Only the arrow keys are used in the expected way. A four-page *Quick Reference* guide helps the user to find the most common commands.

PC/VI uses DOS's ANSI.SYS for screen I/O, which allows PC/VI to run on a large number of machines, but also makes screen updating relatively slow. The manual recommends buying Hersey Micro Consulting's FANSI-CONSOLE, a commercially available replacement for ANSI.SYS, to speed up screen I/O (see "FANSI-CONSOLE," Product Watch, John Walkenbach, January 1987, p. 180).

PC/VI comes with several different executable versions to improve performance in different environments. Versions are available for machines with an IBM PC-compatible BIOS and for those with 80186 instructions.

The documentation, while better than the actual UNIX **vi** manual, is still not very good. It lacks an index, and the table of contents is almost useless because the visual-mode commands are listed by keystroke rather than by name.

For the UNIX programmer already familiar with **vi** and wishing to avoid learning an entirely new editor, PC/VI provides a full PC implementation and may be a reasonable choice. For most other users, however, several better options should be considered.

Lattice, Inc. The Lattice Screen Editor (LSE) is a relatively plain text editor, with only 48 commands and support for a maximum of two editing windows. For many programming tasks, however, it is more than adequate.

LSE works only on files that will fit in memory. It addresses the memory model problem by providing two different executable files called LSE.EXE and LSED.EXE. The smaller and quicker of these two is LSE.EXE, with a maximum file size of about 40KB. LSED.EXE is larger and slower and can handle any file up to the size of the memory remaining in the system—more than 400KB on a 640KB system. Except for a

noticeable difference in speed between the two files, they are identical.

Primarily a key-driven editor, LSE maps most of its commands to key sequences. It also uses command menus for many of the more complex editing functions, such as block manipulation and searching. The command menus can be accessed either by a single key (F1) that goes to the main command menu or by keys that go directly to the next level of menu choices.

LSE makes reasonable use of the numeric keypad keys, and all behave about as expected. It does not do as well with the ten function keys because it relegates seven of them to various types of help. While quick access to help is useful, putting common editor functions on those keys perhaps would better serve the user.

A keyboard reference card also would be a helpful addition. This problem is partially addressed by a command list in one appendix and by a respectable index, as well as by on-line help that lists the command-to-key mappings by command category. The manual is brief but clearly written. While short on examples, it is probably more than adequate for its intended audience.

Although LSE does not have a large set of commands, it has all of the basic commands. Its character, word, and block-manipulation facilities are adequate, and its searching capabilities are more powerful than those of some editors. It offers both a basic string-search function and one that works on UNIX-style regular expressions.

LSE's macro capabilities are somewhat limited—only 10 macros can be active at once. This is not a serious limitation, because macros can be stored in files and loaded when needed. Macros in these files can be edited using the standard LSE command abbreviations.

LSE allows a great deal of customization, both for the environment and for command-to-key mappings. When started up, it reads a configuration file, LSE.DAT, which the user can edit using a program called LSEINST. The user can change the keystroke mapping of any command—for example, to make better use of the 10 function keys—and also can set LSE to support a variety of monitors or terminals. In addition, like most of the other editors, LSE lets the user customize help and error messages.

LSE is designed to work with the Lattice C compiler. When the first window of LSE contains a program's source code and the second window contains the Lattice C error messages for that code, a command can be executed to find the source line that corresponds to the next error.

LSE is a solid, but not outstanding, basic text editor. It offers a reasonable command set and acceptable (if somewhat slow) performance.

Lugaru Software, Ltd. Epsilon, from Lugaru Software, is based on the EMACS text editor (as is UniPress Emacs below).

EMACS, which supports multiple windows and buffers, was developed by Richard Stallman at MIT's Artificial Intelligence Labs in the early 1970s and was first implemented on the PDP-10, a mainframe computer by Digital Equipment Corporation. EMACS was provided free to other computer sites and quickly became popular at many universities. Its popularity led to commercial products for other computers and operating systems, notably UNIX.

EMACS uses three different types of key sequences for commands. The first type uses the Ctrl key with one or two characters. For example, **forward character** is Ctrl-F and **end of line** is Ctrl-E. Less frequently used commands consist of two characters. For example, **save file** is Ctrl-X followed by Ctrl-S.

The second type of command uses a *meta* key that turns on the eighth bit of a character. The PC versions of EMACS typically use Alt as a meta key, although they also support Esc as a meta-prefix key because it is used on many minicomputer implementations. Meta commands work on syntactic units, such as words and sentences, rather than on characters and lines. For example, **forward word** is Alt-F.

The third type of command is invoked by pressing Alt-X to enter command mode, then typing the command on a command line. This allows access to the full set of EMACS commands, including those that are not assigned to a particular key sequence.

EMACS allows the user to change any command-to-key mapping. It also lets the programmer define macros either by instructing EMACS to record keystrokes or by using a macro language that is a complete, powerful programming language. The original EMACS used the editing language TECO, whereas newer versions of the editor use a macro language based on LISP or C.

Epsilon is a faithful recreation of the EMACS editor: anyone familiar with EMACS will find it complete and simple to use. It is a powerful editor, with all of the expected text manipulation facilities. Its search-and-replace functions can use UNIX-style regular expressions. It also supports any number of editing windows and can handle any size file,

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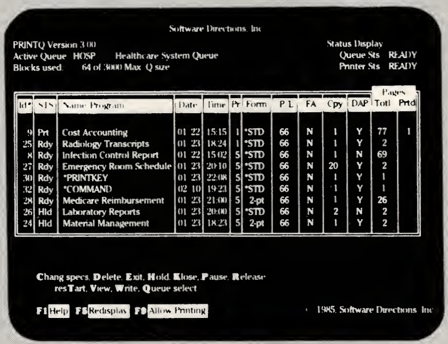

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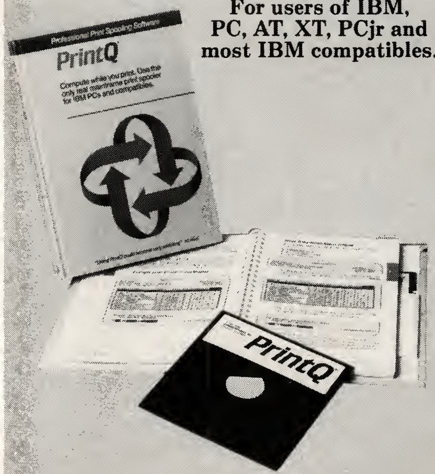

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Epsilon uses the EMACS concept of *modes*. (In this context, the term has a different meaning from the command modes of PC/VI.) Every buffer has a mode that determines how certain commands and features are handled. A file that is written in C is edited in C mode, which includes such features as brace balancing and automatic indention. A buffer's default mode is determined from its file-name extension. An extension of .c or .h, for example, invokes C mode. A particularly useful EMACS mode that Epsilon supports is *dired* (directory edit), which allows the user to edit a directory listing, deleting or moving files.

Users can add or modify modes. Epsilon's commands and features are implemented in Epsilon Extension Language (EEL), which is a language similar to C. The EEL source code to all the commands is provided so the user can add new commands and change the functions and mappings of existing commands. This information is read in a compiled form when Epsilon starts.

Epsilon's macro facility, which records a sequence of keystrokes for later playback, and its ability to add new commands make it, like any editor based on EMACS, completely extensible.

Epsilon also provides a special process buffer that can run any well-behaved DOS process whose I/O is done only via DOS calls. Although this limitation excludes many programs, it does leave some important ones, notably COMMAND.COM, which allows the user to execute any normal MS-DOS command from within the process buffer. The command's output is placed as text into the process buffer, and this text can be moved from this one process buffer to any other buffer. Text also can be moved into the process buffer and used as input to the DOS command that is executing there.

The user can leave the process buffer and enter another buffer, even while the process buffer is still running: the program in the process buffer then runs in the background, allowing a simple type of multitasking. This background process obviously can affect the performance experienced by the user editing in another window.

This feature is especially useful in a programming environment because compilers also can be run in the process buffer. The user can start up a compiler in the process window and then switch to another window and continue editing. If the screen is split into multiple windows, one of which is the process window, the user can see the compilation output while continuing to edit. Output that scrolls out of the window can be viewed using standard cursor-movement commands within the process window.

Epsilon also aids the compilation process by parsing the error output of many popular compilers. A single command takes the user to the next error line in a source file and displays the error on the bottom of the screen. Epsilon comes with support for the error output of both the Lattice C and Microsoft C compilers. Because Epsilon is extensible, the programmer can adapt it to support other compilers and assemblers, as well.

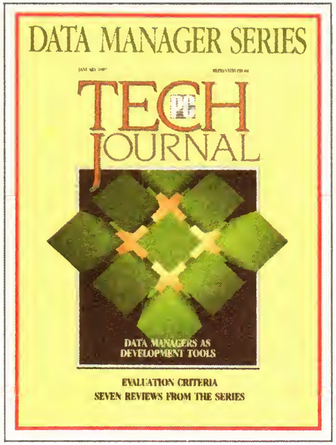
The documentation is well written but intended for the programmer. The on-line help provides concise but adequate reference material. The manual teaches the concepts of EMACS and explains individual commands. A good tutorial leads the user through the important concepts and commands.

Epsilon is an extremely powerful text editor. Anyone who is familiar with EMACS or who is seeking a great deal of editing power and extensibility will find Epsilon very appealing.

MIX Software. MIX Editor in many ways seems like a more powerful version of Lattice's LSE, with a somewhat larger set of commands (more than 100) and a solid macro language.

It is primarily key driven, but also offers an optional command line. Although any command can be mapped to a key sequence of the user's choosing, MIX Editor's standard key mappings omit some commands so that the command line is necessary at first. Many of its commands are mapped to the keys used by WordStar, making it easy to learn for those familiar with that word processor. All of its commands have two-letter abbreviations that can be used as a language, both for accessing commands from the command line and for creating macros.

Large files are handled by keeping only part of the file in memory and the rest on disk in temporary files. However, the management of data flow between memory and files is controlled manually: when the user has filled the memory buffer and wishes to access more of the file, he must move some of the file buffer out to disk and then load more of the file. While MIX Editor supplies macros that aid in the most common occurences of this problem, this type of text management can still be annoying. The user also must be careful when working with large files, because



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many commands, such as search-and-replace functions, work only on the portion of text within the file buffer.

This problem is alleviated somewhat by the fact that the text buffer is large, up to 500KB on a system with 640KB of memory. When the editor is invoked directly from DOS, all but the largest files will be loaded in their entirety. If the editor is used from within another application, however, the buffer will be much smaller, and manual text transfers might be required.

MIX Editor offers a much larger command set than LSE, with more than 100 functions that supply all basic editing capabilities and some special functions. Its searching functions, however, offer only string searches, without any type of regular expression. It supports a maximum of two simultaneous editing windows. Deletion buffers do persist across editing windows, so it is easy to move text between the two files.

MIX Editor also supports several useful DOS functions beyond the ability to start up a new DOS shell. From within the shell, the user can examine files and directories and delete files.

Its macro capabilities are very powerful, with no limit on the number or length of the macros the user can define. The user defines macros in the command mode, supplying a name or key sequence for each macro and then giving the commands to be executed. The macro can be activated either by a two-letter command name or by pressing the sequence of keys to which its commands are mapped.

These macro definitions can be saved as text and edited, but only in the set-up file that MIX Editor reads as it is loading. A utility called SETEDIT allows the user to change the set-up file. This file can contain the definition of any number of macros and any number of TRANSKEY commands, which map commands to key sequences. In this way the editor can be customized even further. The user can build different set-up files, each of which provides an editor that behaves differently.

MIX Editor also provides some commands and macros that support routine programming tasks, such as automatic indenting and numbering functions, and several macros for working with the MIX C compiler that, for example, let the user compile and link the program while in the editor.

MIX Editor assigns the appropriate functions to the numeric keypad keys, and all behave logically. It also maps many common functions to the 10 function keys. Unlike its other standard key mappings, it does not use these function keys in the same way as WordStar. Once learned, however, the function keys provide most of the common editing functions that are not covered by the numeric keypad.

No quick reference card is provided, and the manual contains no single place where all of the key-to-command mappings are listed concisely. This forces the user to consult the index to find the correct page for each command. The manual is otherwise clear and concise, although short on examples. The on-line help is also reasonable and partially addresses the problem of finding the correct key sequence for a command. In order to invoke help, the user must enter one of seven specific topics, which the help function does not automatically list. The command HELP HELP displays the topics, but it adds one more level to the process of finding desired information.

MIX Editor provides all the important editing functions with reasonable performance and offers a complete macro language. It is not as powerful in some areas, such as window management, as those editors based on EMACS, but it is a solid text editor.

Solution Systems. BRIEF was written by UnderWare, Inc. and is published by Solution Systems. While not based on EMACS, it is somewhat similar. The commands are comparable in name and function, but are mapped initially to different keys. Like EMACS, it can be configured automatically on the basis of the extension of the file being edited, it allows changing the mapping of commands to keys, and it can be extended with a powerful command language.

Although BRIEF is philosophically similar to EMACS, it is very much a PC-based product. Its initial command mappings make extensive use of the function keys and numeric keypad of the PC. BRIEF also has a powerful undo capability that can be used on any commands—with the exception of disk operations and **undo** itself. The undo stack holds 30 commands by default, but the stack can be changed to hold a maximum of 300 commands.

Like those editors based on EMACS, BRIEF is very powerful. Its search-and-replace functions allow the use of regular expressions, and it supports multiple buffers and windows. The number of buffers is limited only by available memory, and the number of windows only by the physical dimensions of the screen. Different windows can display different buffers or different parts of the same buffer. To help the user keep

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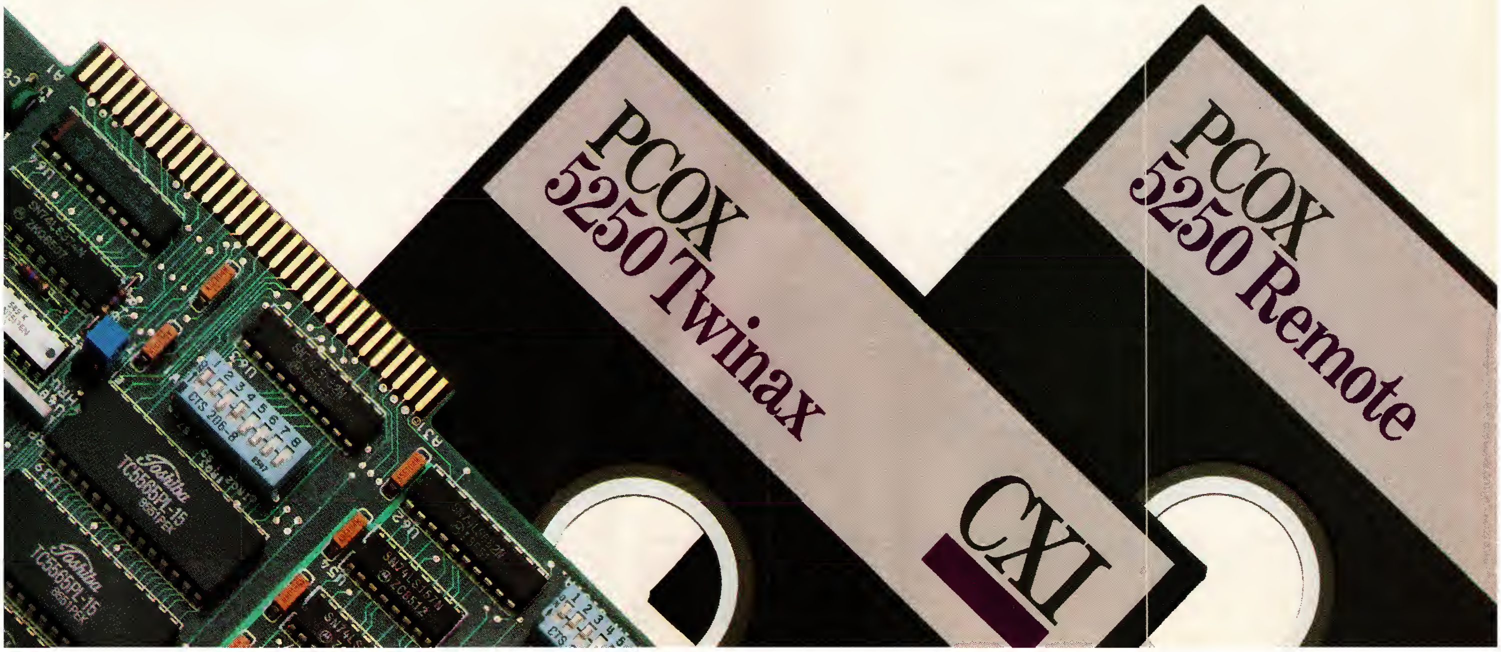

track of the window in which he is working, BRIEF uses a status line that includes such information as the file name and current line on display. To keep track of buffers, the user may display a list of open buffers in a pop-up window; each entry on the list shows the name of the file in the buffer and whether or not it has been modified.

BRIEF allows two types of macros. The first is defined by recording a sequence of keystrokes. This facility is used for ad hoc definitions during a single editing session: only one such macro may be defined at a time and it cannot be saved from one editing session to another. The second type of macro is written in a powerful macro language similar to the UniPress Emacs version of LISP, but with some influence from C. These macros must be compiled before they are loaded in order to increase performance.

BRIEF also provides several useful sets of standard macros. One gives BRIEF some of the capabilities of a simple syntax-directed C editor, performing brace balancing, simplifying indention, and providing statement templates.

Another set of macros allows the programmer to compile programs from within BRIEF and then examine the resulting errors. This facility supports C compilers from Wizard Software Systems, Inc., Lattice, Inc., and Computer Innovations, Inc., as well as the compiler for BRIEF's macro language. It is written in BRIEF's macro language, and the source code is supplied so that it can be modified to support other compilers and assemblers. Users can change any command-to-key mappings and can add new commands. These capabilities are supported by a start-up file that contains those mappings and the definitions of many of the commands.

The documentation is well done. While BRIEF seems intended for programmers, its documentation attempts to reach a wider audience. The manual's biggest weakness is that it has five separate sections, some of which have their own index and some without an index. However, a major revision of the manual is in progress and will be released with the next version of this editor. BRIEF also comes with a quick reference and a tutorial that teaches its basic concepts. The editor can be learned easily by using this tutorial and the reasonable on-line help facility.

BRIEF is suitable for a large class of users, from novices to serious PC programmers. If the user does not need compatibility with an existing editor, BRIEF is an excellent choice.

UniPress Software, Inc. UniPress Emacs, like Lugaru's Epsilon, is a full PC implementation of EMACS. One area where UniPress Emacs excels is its libraries. Because UniPress Emacs has been available for years on other systems, users have written a large body of libraries for it that support many tasks, from capitalization to a rudimentary database.

Because of these libraries, UniPress Emacs provides more modes than Epsilon and better support for the modes they both provide. For example, its C mode has more statement templates, with facilities that support most of the major C constructs. The user also can change these templates in every way, from the abbreviations used to where braces are placed. UniPress Emacs provides a compile and next-error facility that works both with Lattice C and with UniPress PSMake (a tool that is similar to the UNIX **make** utility).

However, some documented features of these libraries do not work. For example, every time paragraphs are justified, the number of spaces after each sentence increases. Another example involves the Lattice C compiler—although UniPress Emacs is documented to work with version 2.0 or later of Lattice C, in version 3.1 it did not pass compiler options correctly and would not return errors. UniPress Emacs comes with the LISP source code for the Lattice library, so the code can be changed to work with version 3.1, but this change should have been made by the vendor itself.

For its macro extension language, UniPress Emacs uses MLISP ("mock" LISP). While not actually a true implementation of LISP, MLISP is very similar to most common variants of LISP. All of the UniPress Emacs libraries are written in MLISP, and the source code is included with the editor. The libraries are stored in separate files. Perhaps because of this, despite using a compiled form of the libraries, UniPress Emacs loads more slowly than Epsilon, which uses only one command file. The many libraries also consume additional memory. For example, the user should have at least 512KB (preferably 640KB) to use all of the C libraries.

Memory management by UniPress Emacs is somewhat primitive. The size of the file that can be edited is limited to the size of a preallocated text buffer. By default, this is 100KB, but it can be changed by means of a SET command at the DOS level. The fixed buffer size is allocated regardless of the actual size of the text file. Making the buffer too small limits the size of text that can be edited, while making it too large limits


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the number of macro libraries that can be loaded and the DOS commands that can be executed from within the editor. A large buffer also affects other editor operations. With a buffer of 170KB or greater, it is not possible to merge a 10KB file into a file of 150KB, even though an existing file up to the size of the buffer could be loaded directly.

The on-line help facility and the documentation are oriented toward those who are already familiar with EMACS. For users new to EMACS, it can be difficult to grasp a basic understanding of the system, and the documentation does little to help. As the first page of the manual states, "The organization of this manual is rather haphazard" and "The best way to learn EMACS is to find a friend who already knows."

WordPerfect Corporation. Program Editor (PE) is included as part of the WordPerfect Library, so it is, not surprisingly, a scaled-down version of the WordPerfect word-processing program.

PE provides the usual set of editing facilities. Its search functions permit DOS-style wild cards but not regular expressions. It also supports only two editing windows at once. However, it offers a broad set of DOS functions, well beyond the ability merely to start a new DOS shell. Without leaving PE, the user can examine directories and files, and can search, copy, and rename files.

For large files, PE uses an invisible buffer management that keeps in memory as much of the file as possible, and then resorts to temporary files when necessary. The only size limitation is that a file can have a maximum of 300 pages. Because the user controls where page breaks occur by entering a hard-page command and because each page can contain up to 65,535 lines of text, the 300-page limit is not a problem.

One unusual and occasionally troublesome characteristic of PE is that it distinguishes between pages and screens. For those accustomed to working with word processors, this distinction is reasonable. However, most programmers are likely to expect page keys, such as PgUp and PgDn, to work on one screen at a time. Instead, they work on actual pages, which are typically several screens long. Other keys—plus and minus on the numeric keypad—can be used to scroll by screen. If the user did not explicitly enter any page breaks, the whole file would be one page, and PgUp and PgDn keys would go respectively to the beginning and end of the file. Fortunately, there is an option that can be used to set the paging keys to work by screen; however, this setting cannot be saved from one editing session to the next.

PE is almost totally key driven. Many of the command keys, however, cause menus and submenus to appear on a status line at the bottom of the screen. The user then must select from these menus to complete the desired operation. While the menus lessen the number of different keystrokes the user must remember, they also force him to use more keystrokes per function than do some of the other editors. Because the command-to-key mappings follow those of WordPerfect, users familiar with the word processor will feel comfortable using this editor. PE also has most of WordPerfect's idiosyncracies, such as asking if a file should be saved even when no changes have been made or even if the edit buffer is empty.

PE assigns logical functions to the numeric keypad keys and 10 function keys, but, like WordPerfect, it assigns four functions to each function key: one function when the key is pressed alone and one each with the Shift, Alt, and Ctrl keys. Because this can be confusing, PE helps the user with color-coded function key templates and appropriately colored plastic keycaps for Shift, Alt, and Ctrl. Used in combination, the template and keycaps tell the user which

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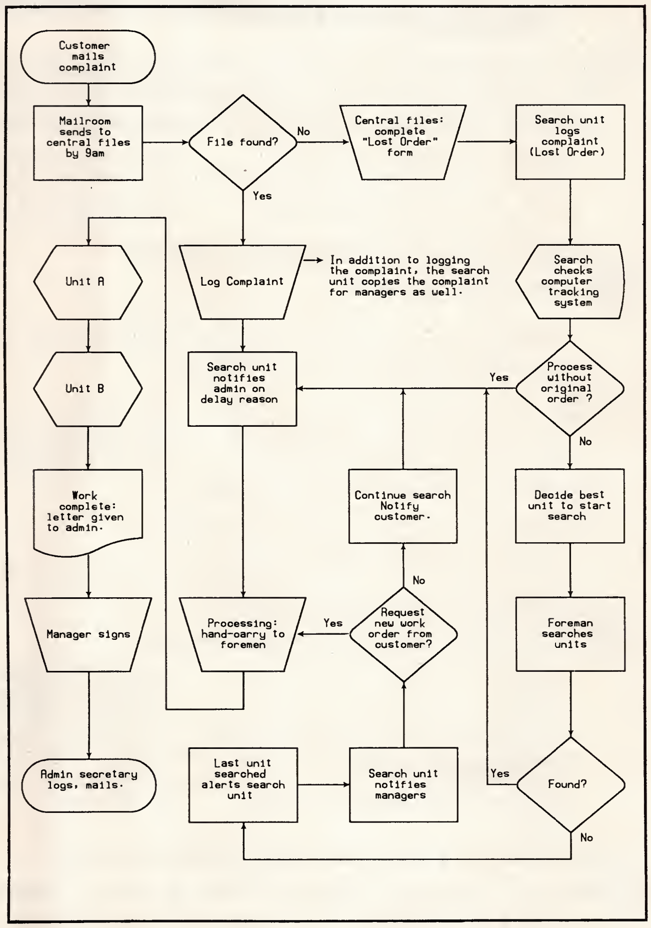

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special key to press with a given function key to execute a particular command. All of the command-to-key mappings are listed in an appendix. The help key, F3, presents a key template as its first screen for quick reference. The documentation is well written, concise, and contains a reasonable index.

Two types of macros are provided. Between them there is no limit to the number or length of the macros that can be defined. One type is triggered by pressing the Alt key and a letter; the other, by name. Both types actually result in a disk file containing a macro's keystrokes, although the name of the first type is fixed to Alt<letter>.PEM (so that PE can find it automatically). Macros typically are defined by recording a set of keystrokes. However, PE comes with a companion product, Macro Editor, that allows the user to edit macro files. This gives the user a macro language for building command sequences, much like in MIX Editor.

However, PE provides no explicit way to reassign any command-to-key mappings directly. Although this is no limitation to those users happy with the WordPerfect command structure, it can be annoying to those who want to customize the editor. As with most of the other editors, the user can customize the PE help files.

The backup capabilities of PE are unusually good. In addition to the expected abilities to save with or without exiting, PE offers the option of timed backups. The user can set a specific time interval at which backups of the current file are automatically made to temporary files on disk. If a power failure or some other disaster occurs during an editing session, when PE next starts the user is given the option of recovering the previous editing session.

PE is a reasonably powerful editor, but it is likely to appeal primarily to those already familiar with WordPerfect. Its feature set and customization abilities fall quite a bit below those of some of the other editors, although they are adequate for many jobs.

MAKING A CHOICE

All of the editors reviewed here provide good basic editing functions. They allow programmers to manipulate text by character, word, line, or block. Each is suitable for some users, but many are limited in their appeal.

VEDIT PLUS is powerful but often cryptic and has not been adapted to the PC particularly well. Because it is available on several microcomputer systems that run the CP/M operating system, it

could be applicable to users who must work in those environments.

Because PC/VI provides a complete PC implementation of the UNIX text editor **vi**, it is a nice alternative for those already familiar with **vi**. However, its odd visual submodes and cryptic nature make it a poor choice for most.

LSE offers basic editing capabilities but is not outstanding in any particular way. Because it is available on other machines, programmers working in those environments may choose LSE. For other programmers, however, more powerful editors are available.

Epsilon is a powerful, extensible, complete editor. Its compatibility with EMACS makes it a good choice for those users already familiar with that editor on other systems. In such areas as documentation and file size, it avoids many of the rougher edges found in some other EMACS implementations.

If the programmer is already familiar with WordStar, then MIX Editor is a natural choice. It offers strong macro and editing capabilities. Its biggest drawback is that the user must manually manage an editing buffer for files that will not fit in memory.

BRIEF also is a powerful, extensible text editor that works well with the PC. While powerful, its features are not inaccessible to the average user. However, its default command structure is not compatible with any major editors on other systems, so the user must learn new editing commands.

The primary strengths of UniPress Emacs are that it is a full implementation of EMACS and is available on many other systems. Because it is widespread, many useful libraries have been developed for it. As a version of EMACS, it is powerful and extensible, but it is a quirky implementation. UniPress Emacs compares unfavorably with Epsilon; it is bigger, slower, not as intelligent in managing memory, and its documentation is extremely difficult for the user unfamiliar with EMACS to understand.

PE is a good choice for the programmer familiar with the WordPerfect word processor. It is a reasonable though not especially notable editor. Its heavy reliance on command menus and its inability to allow changes in the command-to-key mappings are likely to trouble many programmers.

If the programmer is already familiar with a word processor or editor from another environment, certain editors take advantage of this knowledge by treating commands and keys similarly, such as MIX Editor and WordStar; PE and WordPerfect; PC/VI and **vi**; and Epsilon or UniPress Emacs and a version of EMACS. For the user with no particular biases who is seeking a powerful editor, either Epsilon or BRIEF is an excellent choice.

Mark L. Van Name is a vice-president and cofounder of Foresight Computer Corporation. William B. Catchings is on the technical staff of Data General Corporation.

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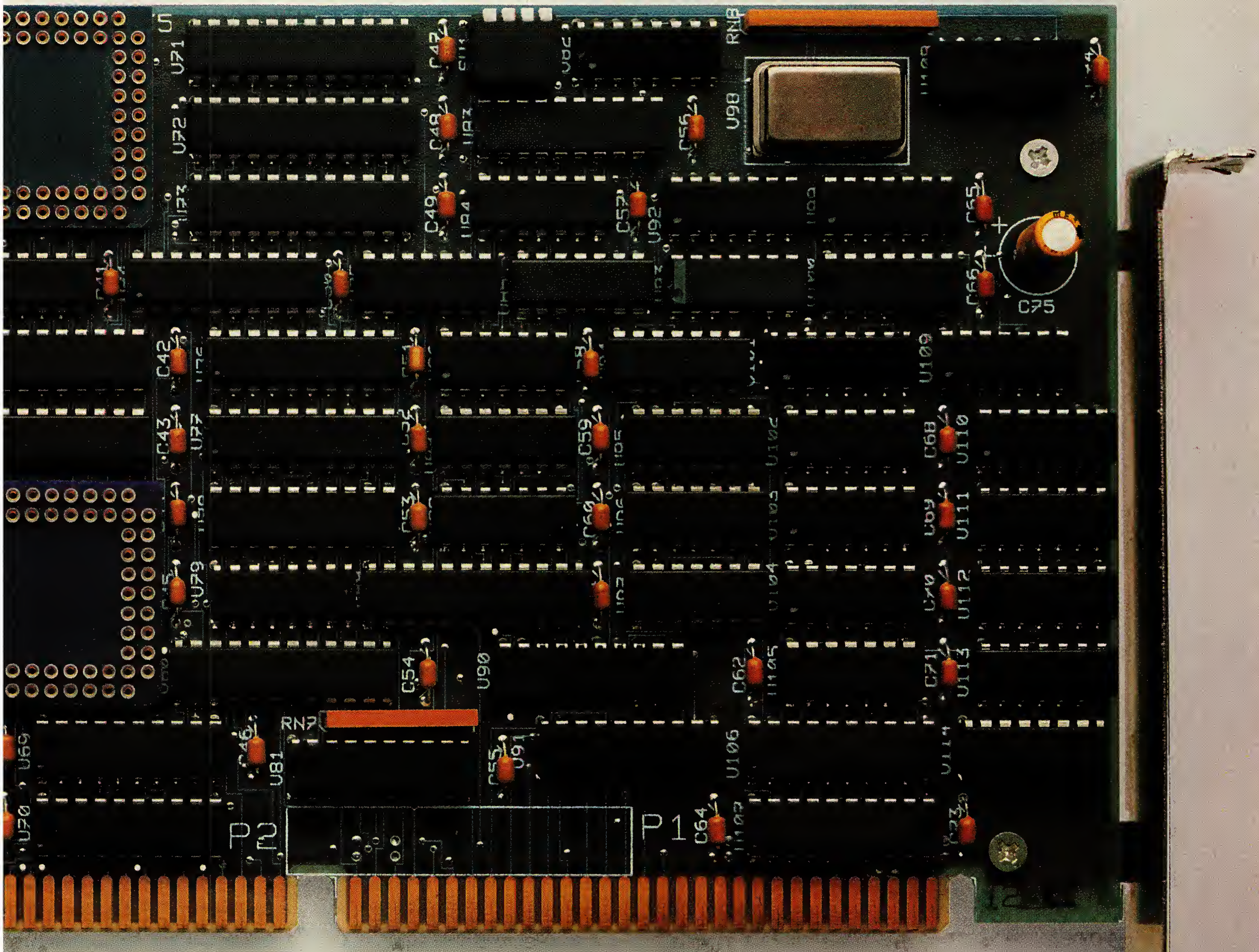

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Command-Line Arguments for FORTRAN

Two assembly language routines can be combined with any FORTRAN program to retrieve command-line data.

JOHN W. ROSS

The ability to retrieve command-line arguments increases the flexibility of a program; it allows the program to be placed into a batch (.BAT) file and supplies replaceable parameters for the program arguments when executing the .BAT file. Using command-line arguments, options can be selected when the program is invoked without the need for user-prompts. Programs acting as filters (that is, modifying a data file, then passing it along for further processing) are much more useful if they accept command-line arguments.

Some C and FORTRAN compilers produce programs that can retrieve command-line arguments. Unfortunately, Microsoft FORTRAN, among other compilers, does not incorporate this feature; this language has no facility for retrieving any data on the command line. Two short, relatively simple assembly language routines presented here will correct this deficiency; the routines can be combined with any Microsoft FORTRAN program to retrieve the command-line data, that is, everything typed after the program name.

AREA OF EXECUTION

If the command-line data are indeed available for retrieval by the program, where does DOS store the command line, and, more importantly, can it be reached? When DOS loads a program for execution, it creates the program segment prefix (PSP) at the base of the program's code segment. This area contains information that DOS uses to control the program's execution. The command-line data are placed into a 128-byte buffer that begins at offset 80H in the PSP. The byte at 80H contains the number of characters (from 0 to 127) typed following the program name. These characters, stored beginning at offset 81H, are the command-line data.

The actual location of the PSP in memory depends on where DOS loads the program when it is invoked. This location can be easily determined because DOS sets the **ds** and **es** registers to point to the PSP when a .EXE program is loaded into memory.

In principle then, all the programmer has to do is view the contents of the **es** register when the program executes, and then use this information to find the PSP from which the command-line arguments can be extracted. The problem with using this method is that FORTRAN has no means of examining register contents, or even examining the contents of specific memory locations, as BASIC's PEEK statement can. In addition, when a FORTRAN program executes, it goes through an initialization process; by the time the user-written portion of the program receives control of the computer, there is no guarantee that either the **ds** or **es** registers will still point to the PSP. Fortunately, it is not difficult to interface FORTRAN programs with assembly language programs written using Microsoft's Macro Assembler (MASM).

REQUIRED PROGRAMS

One way to gain access to the contents of the registers when a FORTRAN program executes is to graft a small assembly language program onto the front of the FORTRAN program that will execute before the main program. This *header* program will save the contents of the **es**

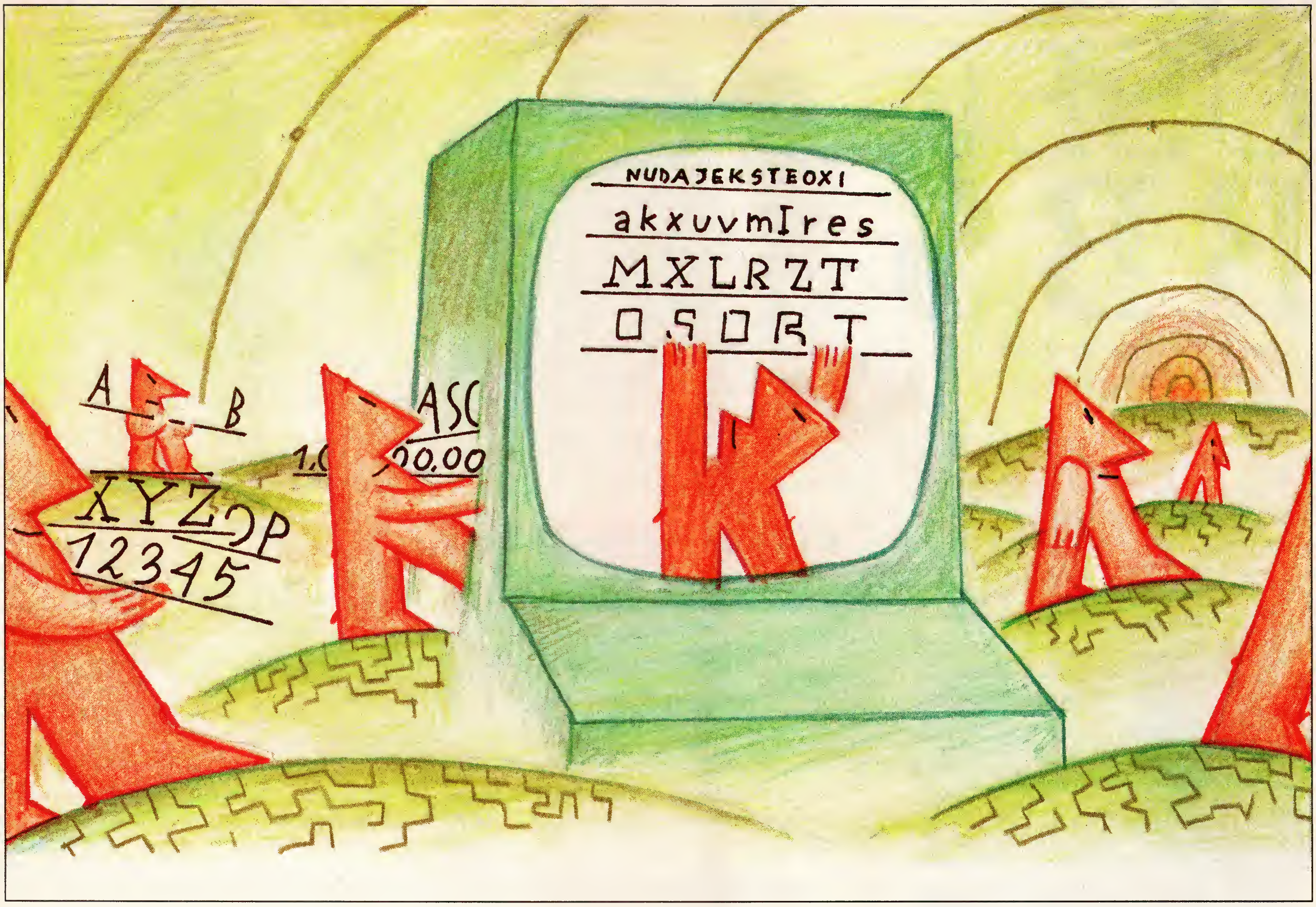

ILLUSTRATION • MACIEK ALBRECHT

register, then transfer control to the normal entry point of the FORTRAN program. Another assembly subroutine is then called to retrieve the contents of the **es** register, and, therefore, the PSP location. Using this information, the command-line data can be accessed.

The header program, although short, presents three distinct problems. First, the header program needs to save the contents of the **es** register in a safe place where the data can be retrieved later. DOS sets aside an area in low memory for just such a purpose: the intra-applications communications area (ICA). The ICA is a 16-byte buffer that is located at 0000:04F0H, which is an area reserved for programs that want to pass information between one another. The header program places the contents of the **es** register in the ICA, and the command-line-retrieval subroutine knows to look for the data there.

The second problem concerns transferring control to the FORTRAN main program. In order to initialize properly, this transfer must be performed at the normal entry point, but how is this entry point determined? The answer lies in compiling and linking the FORTRAN program, being sure to specify the /MAP switch when invoking the linker; this causes the linker to generate a .MAP file. Figure 1 shows the final portion of this file. There, on the final line, is the address of the program entry point, relative to the start of the program. Now, all that is necessary is to locate a label in the .EXE file with this address. For this, the .MAP file is used again. Figure 2 reveals the section that contains the label **_astart** in the Publics by Value (which has an address of 02C9:0018H). This is the address to which the header program must jump when it is completed.

The final problem is how to ensure that execution begins with the header program. This problem is handled by the assembler and linker. As shown in listing 1 (HEADER.ASM), after storing the contents of the **es** register in the ICA, the header program then branches to **_astart**, the FORTRAN program's entry point. Note that the final end statement specifies the header as the program entry point. Now, if object files are linked as follows: [header] + [FORTRAN main program] + [other .OBJ files], the execution is ensured to begin with the header program.

COMMAND LINE RETRIEVAL

One of the first tasks the FORTRAN program performs is to retrieve the command line in order to check for files, option switches, parameters, and so on. This is done by invoking the assembly language function, COMLIN.ASM, shown in listing 2. This integer function accepts one CHARACTER*127 parameter into which it returns the command-line data, if any. The function also returns a value that is equal to the length of the command-line data string returned.

If no characters were typed after the program name (that is, if there were zero bytes of command-line data), the function returns to the main program with a value of zero. Otherwise, the function first fills a variable that will contain the command-line data with blanks, then copies the actual command-line data into this variable.

FIGURE 1: *End of LINK .MAP*

```
045F:08A6        __FFoutput_processors
045F:08AA        __FFinput_processors
045F:08AE        __FFnum_fetchers
045F:08B2        __FFchn_fetchers
045F:08B6        __FFbyte_senders
045F:08BA        __FFunf_rtn_tab
045F:08C6        __FFflt_decoder
045F:08C8        __FFflt_encoder
045F:08CA        __FFhex_handler
045F:09C8        _edata
045F:0C30        _end
0000:9876  Abs   __acrtmsg
0000:9876  Abs   __acrtused

Program entry point at 02C4:0016
```

The last line shows how LINK indicates the segment:offset address of the linked program's entry point.

FIGURE 2: *Publics by Value*

```
0009:2B64        __FF_MCPY
0009:2B8D        __FF_MSET
02C4:0016        __astart
02C4:00CC        __cintDIV
02C4:00D5        __amsg_exit
02C4:00E8        __aFlmul
02C4:00E8        __aFulmul
02C4:011C        __FF_DBGMSG
02C4:0199        __FF_MSGBANNER
02C4:01C3        __FF_writestring
```

The third line gives the label of the program's entry point address shown at the end of the .MAP file.

FIGURE 3: *FORTARG LINK Dialog*

```
Microsoft (R) Overlay Object Linker  Version 3.55
Copyright (C) Microsoft Corp 1983, 1984, 1985, 1986.  All rights reserved.

Object Modules [.OBJ]: header+fortarg+comlin <cr>
Run File [HEADER.EXE]: fortarg <cr>
List File [NUL.MAP]: <cr>
Libraries [.LIB]: <cr>
```

Link is instructed to load .OBJ files in the following order: HEADER, FORTARG, COMLIN. The executable file produced is to be named FORTARG.EXE.

FORTRAN expects a function that returns a short integer result to return it in the **ax** register. If a function returns a long integer, FORTRAN expects the low-order bits to be returned in **ax**, and the high-order bits to be returned in the **dx** register. COMLIN always returns a short integer; however, it always clears the **dx** register, so it does not matter if COMLIN is declared as a short- or long-integer function in the main FORTRAN program.

FORTARG.FOR (listing 3) shows a typical application. FORTARG expects a file name to be supplied on the command line. It calls COMLIN to determine what the file name is. If COMLIN returns a result of zero, it simply means that the file name was not supplied on the command line, so FORTARG prompts the user for the file name.

An important point to realize is that COMLIN does no parsing of the command line; therefore, the command-line-data variable always will start with a separator (which is usually a blank) that separates the program name from the command-line data. That is why FORTARG defines FILNAM to start with the second character of COMARG:

```
FILNAM = COMARG(2:)
```

FORTARG assumes that it was invoked by the user typing

```
A> FORTARG MYFIL.DAT
```

that is, with one separator between FORTARG and MYFIL.DAT. If desired, a way to remove leading separators can be developed with minimal difficulty.

To build this program, HEADER and COMLIN are assembled with MASM, which produces the two object files, HEADER.OBJ and COMLIN.OBJ. The FORTRAN program FORTARG is compiled to produce FORTARG.OBJ. Figure 3 shows the dialog required with the linker to build FORTARG.EXE, assuming all files (including the FORTRAN libraries) are in the current directory. The <cr> symbol indicates that a carriage return is to be entered. Once linked, FORTARG may be executed.

The technique presented here to retrieve arguments from the command line greatly enhances the flexibility of any FORTRAN program. Insight gained into the workings of FORTRAN, the linker, and DOS should be helpful in other applications. In addition, assembly language subroutines can help to extend the capabilities of FORTRAN, or any other language.

John W. Ross, Ph.D., is a senior consultant at the Center for Large Scale Computation at the University of Toronto in Ontario, Canada. He is also president of Jayar Systems.

LISTING 1: HEADER.ASM

```
; Program to store program segment prefix in intra-applications
;   communications area, then transfer control to a version 3.3
;   Microsoft Fortran program
; Copyright (C)  John W. Ross  1986

ICA      equ     4f2h    ; intra-applications communication area

extrn    __astart:far    ; Fortran program entry point
cseg     segment para public 'code'
public   header
header   proc far
         assume cs:cseg,es:nothing
         push ds         ; save the data segment
         xor dx,dx       ; zero the data register
         mov ds,dx
         mov bx,ICA      ; bx now points to the ICA
         mov dx,es       ; store the extra segment (psp
         mov [bx],dx     ;   location) in the ICA
         pop ds          ; restore ds
         jmp __astart    ; jump to the Fortran program's entry point
header   endp
cseg     ends
         end     header  ; make this program the entry point
```

LISTING 2: COMLIN.ASM

```
; Microsoft Fortran-callable function to retrieve command line data
; Copyright (C)  John W. Ross  1986

; Calling format:

;    N = COMLIN (COMARG)
;
;        COMLIN  must be declared to return an integer (short or long)
;
;        N       a short or long integer--the number of characters on
;                the command line following the program name
;
;        COMARG  a CHARACTER*127 variable--the portion of the command
;                line which follows the program name

; equates
psp_seg equ     4fh     ; program segment prefix segment
psp_off equ     2       ; program segment prefix offset
max_len equ     127     ; length of command line data
len_off equ     80h     ; offset of command line length
blank   equ     20h     ; blank character

cseg    segment 'code'          ; define the code segment
        assume  cs:cseg

public  comlin                  ; make it known outside
comlin  proc    far

        push    bp              ; save Fortran's registers
        mov     bp,sp
        push    ds

        push    ds              ; point the extra segment at ds
        pop     es

; retrieve the number of characters on the command line
        mov     dx,psp_seg      ; load the location of the psp
        mov     ds,dx           ; into bx
        mov     bx,psp_off
        mov     dx,[bx]
        mov     ds,dx           ; the psp is now the data segment
        mov     bx,len_off      ; offset for the command line length
        mov     ah,0
        mov     al,[bx]         ; command line length now in al
        cmp     ax,0            ; if its zero, return
        je      exit

; first, blank out COMARG
        les     bx,dword ptr[bp+6]      ; the address of COMARG
        xor     cx,cx           ; zero cx
        mov     cl,max_len      ; set up for looping
clr:    mov     es:[bx],byte ptr blank
        inc     bx
        loop    clr

; now, put the actual command line data into COMARAG
        les     bx,dword ptr[bp+6]      ; the address of COMARG
        mov     cx,ax           ; # of characters on command line
        mov     si,len_off+1    ; where the command line data starts
load:   mov     dl,[si]         ; get a character
        mov     es:[bx],dl      ; move it to COMARG
        inc     bx
        inc     si
        loop    load

exit:   mov     dx,0            ; so we can return a long integer
        pop     ds              ; restore Fortran's registers
        mov     sp,bp
        pop     bp
        ret     4

comlin  endp
cseg    ends

        end
```

LISTING 3: FORTARG.FOR

```
C     PROGRAM TO DEMONSTRATE THE OPERATION OF HEADER.ASM & COMLIN.ASM
C     JOHN W. ROSS  1986

      INTEGER COMLIN
      CHARACTER COMARG*127, FILNAM*64, TEXT*70
      IF (COMLIN(COMARG).EQ.0) THEN
        WRITE (*,'(1X,A\)') 'Input file name ... '
        READ (*,'(A)') FILNAM
      ELSE
        FILNAM=COMARG(2:)
      ENDIF
      OPEN (1,FILE=FILNAM,STATUS='OLD')
1     READ (1,'(A)') TEXT
      WRITE (*,*) 'FIRST LINE: ',TEXT
      CLOSE (1)
      END
```

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```
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WHERE WORKTONTAB.ENUM = EMPLOYEES.ENUM-
AND WORKONTAB.PNUM = PROJECTS.PNUM-
AND PROJNAME = 'ALPHA'

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projname = 'Alpha'
```

A typical SQL command and the ZIM equivalent.

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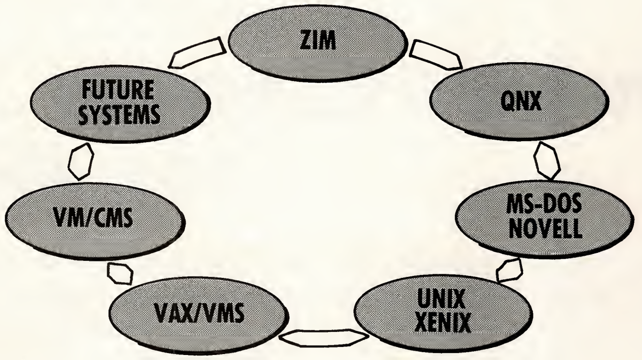

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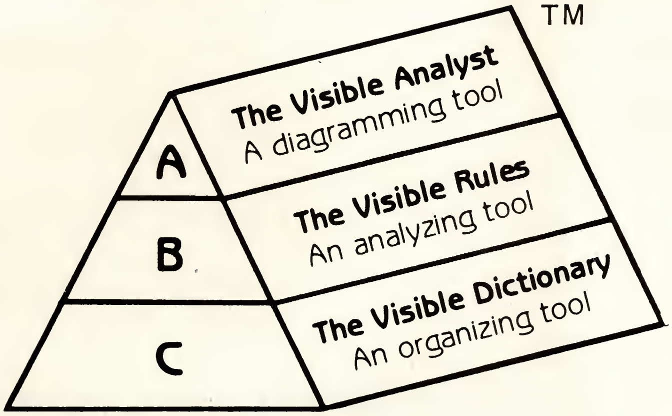

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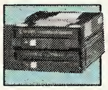

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Cybernetic Micro Systems, Inc.'s dBug/EGA, version 3.0 is a full-screen, 8086/286 symbolic debugger for assembly language programmers who are developing applications for enhanced graphics adapters. As the name implies, an enhanced graphics adapter is required for its use. Special support features provide direct manipulation of the graphics hardware to accomplish tasks more easily than is possible with most other debuggers.

The highly functional user interface splits the screen vertically into two halves. The left half displays assembly language source code with labels and symbols, the 8086 registers, eight bytes of memory, the user's stack, on-line help, and a command entry area. The right half is used in one of three ways: it displays and updates a flow diagram of the executing program section; or it is a font editor allowing the creation and storage of new characters; or it can be a color palette display that allows the altering of any palette register.

Unlike debuggers that append a symbol table to the end of an executable (such as Phoenix PFIX) or read a symbol file (such as Microsoft SYMDEB), dBug/EGA directly reads the assembly language list file. Only the IBM and Microsoft assemblers are supported.

A helpful feature of dBug/EGA is the flow diagram generator. As a program is traced, the flow is graphically illustrated in realtime. While this feature is not necessary to run dBug/EGA, it allows the user to add special comments to the source code that will display branching and add descriptive information to the flow. Two standard flowchart symbols are used: the process box (rectangle) and the decision box (diamond). The sequences, ; : **Process** and ; ? **Decision**, will show "Process" and "Decision" in the respective boxes. Figure 1 and photo 1 illustrate the relationships between the source code and the flow diagram. The only way to generate flow diagrams is to place special comments in the source code.

An unusual feature of dBug/EGA is the source-code window. As it is executed, source code is displayed in this window. The next instruction to be executed is indicated by an asterisk. Code that has been executed flows off the top of the screen as code that sequentially follows the next instruction flows up from the bottom of the screen:

```
  past code
  last instruction
* next instruction
  following (future) code
```

The execution of branch instructions causes the future-code display to change. The last instruction and past-code information stay the same as they flow off the top of the screen; they act as an instruction-execution history instead of a display of the code immediately preceding the next instruction to be executed (see figure 1).

dBug/EGA imposes several unique restrictions on programmers. For example, opcodes should *not* follow labels on the same line but should be written on the next line. This implies that a substantial amount of time might be spent separating labels in large preexisting programs. In multimodule programs, only one module can be debugged symbolically, and it must be the first one linked. For most .EXE programs, this should not be a problem.

New characters can be created easily with dBug/EGA. Upon selecting this option, the right half of the screen is transformed into a character-font editor, an 8-by-14 array of plus-sign characters. A cursor is represented by a highlighted plus. Pressing the plus key changes the represented pixel from a plus to a square; pressing the minus key changes the pixel back to a plus sign. Fonts created by dBug/EGA can be saved to disk and reloaded later.

Any EGA palette register can be altered by entering Cn=color, where Cn stands for register *#n*. For example, C3=2 will change color register 3 to green (=2). This feature allows the user to try new color schemes in a graphics program, using up to 16 colors. The Cn commands are always active in the debugger. When the palette command is issued, all of the color registers are displayed in the flow window.

dBug/EGA supports many other common debugging features, including examine/modify registers and memory; port I/O; multiple register traps; memory trap; and multiple breakpoints.

The 110-page manual is complete and easy to follow. The installation process is straightforward, and it takes little time to work through the demonstration debug session.

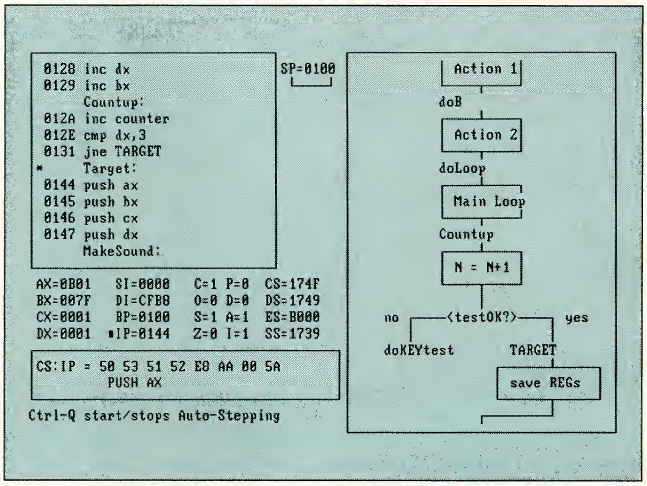
In a test situation, dBug/EGA was used to trace the execution of a simple program that performs the following instructions while initializing:

FIGURE 1: *Annotated Source Code*

```
0128                    doLoop:                   ;:Main Loop
0128                            inc     dx
0129                            inc     bx
012A                    Countup:                  ;:N = N+1
012A  FF 06 0000 R              inc     counter
012E  83 FA 03                  cmp     dx,3
0131  75 11                     jne     TARGET  ;?testOK?
0133                    doKEYtest:                ;: Key Status
0133  E8 0151 R                 call    SUBroutine
0136                    doA:                      ;: Action 1
0136  24 0F                     and     al,0Fh
0138  FE C0                     inc     al
013A                    doB:                      ;: Action 2
013A  BA 0000                   mov     dx,0
013D  E2 E9                     loop    doLoop
  :                       :
0144                    Target:                   ;:save REGs
0144  50                        push    ax
0145  53                        push    bx
0146  51                        push    cx
0147  52                        push    dx
0148                    MakeSound:
```

The comments included in this source code are used to generate the action and decision boxes that are illustrated in the logic flow diagram shown in photo 1.

PHOTO 1: *Sample Screen*



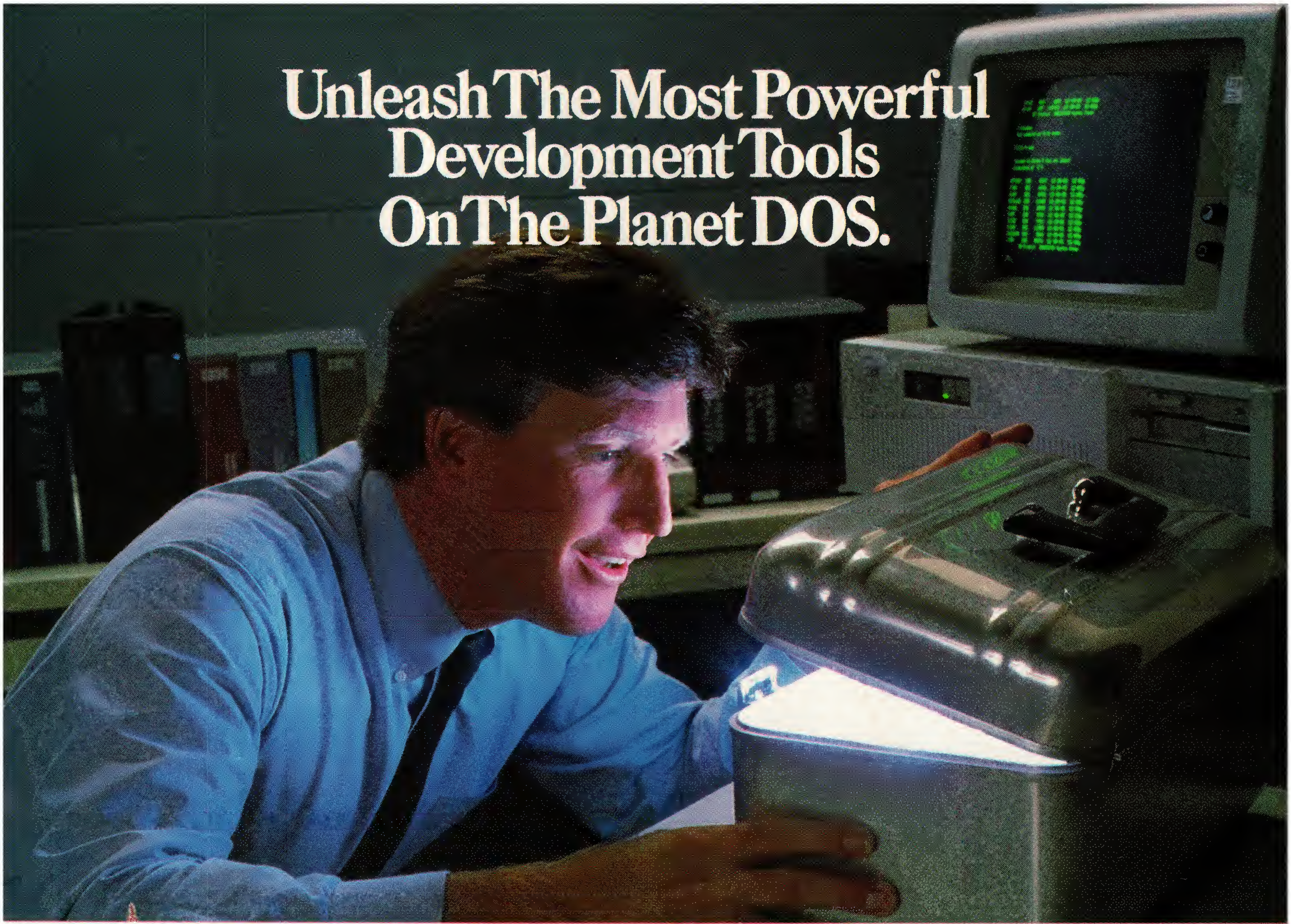
The location of the next instruction to be executed is indicated by the * in the box at the left. The instruction itself is shown in the lower left-hand box on the screen.

```
MOV     AH,0FH
INT     10H
MOV     AH,00H
INT     10H
```

These two calls to the ROM/BIOS video service clear the screen. They also clear the debugger screen and display gibberish. A support person at Cybernetic said that the user screen is not restored with the trace command, implying that a user cannot trace through a display routine because screen writes overwrite the debugger screen. If the user initiates the program from dBug/EGA and allows it to run until it terminates or reaches a breakpoint—rather than tracing program execution—the debug screen is restored.

To date, no one has produced a "do-it-all" debugger. Unlike other debuggers, dBug/EGA permits access to enhanced graphics hardware; yet, it is not the ultimate debugger.

—GUY QUEDENS



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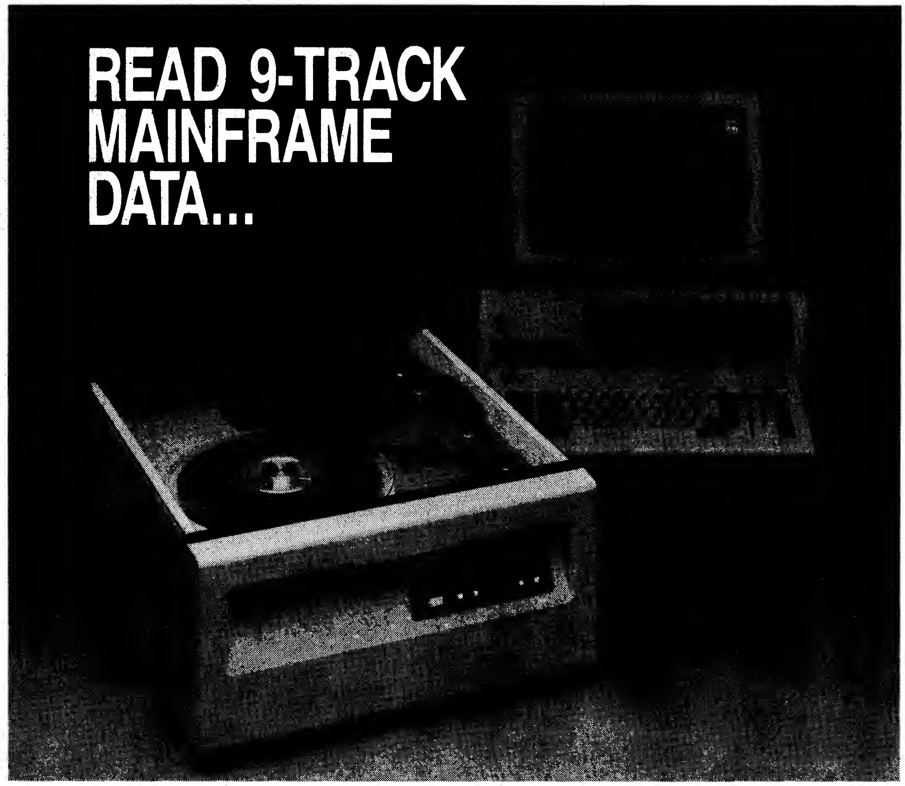

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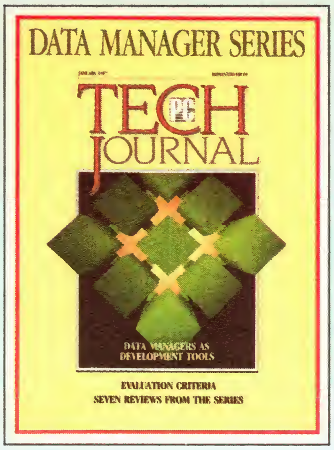

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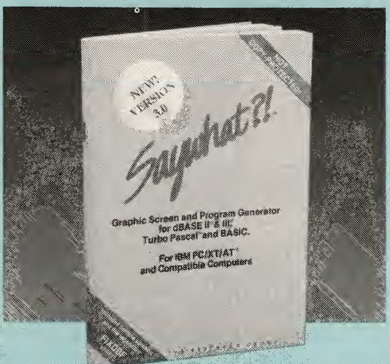

CIRCLE 359 ON READER SERVICE CARD

Creating exact text images of a screen or writing general-purpose utilities to display a screen within an application can be time consuming for developers. Saywhat?! from The Research Group provides a simple, language-independent utility that is capable of defining and displaying screens.

A general-purpose screen generator, Saywhat?! uses a memory-resident program to display the screens from any application. Using an option that is available during screen generation, data entry fields can be specified and source code generated to perform simple data entry. The source code for data entry is completely independent of the screen image. Source code can be generated to perform the data entry only in Pascal, dBASE, or BASIC.

Saywhat?! supports the Hercules Graphics Card, the IBM Color Graphics Adapter (CGA), and Enhanced Graphics Adapter (EGA). It provides a single-screen editor that is designed for building screens easily. The editor allows a developer to build a screen or a window much faster than is possible with normal text editors. Saywhat?! provides excellent access to the video attributes, allowing control of the IBM extended character set, color, intensity, underline, and blinking. The characteristics apply to foreground and background text on a character-by-character basis. Box drawing is impressively simple. A user selects the box type, then positions the cursor to one corner of the box and enters *B*, then positions the cursor to the opposite corner and enters *B* again. Voilà, the box appears. Other features of the screen editor are block erases, copies, moves, box fills, paints, and an undo command. Final images of the screens are saved in compressed format with a separate file for each.

The memory-resident program, VIDPOP, must be installed to display screens. It is designed to work with any language, including DOS batch files. The documentation states that this program does not have to be installed last.

Control is passed to VIDPOP by attempting to display a control sequence on the screen. The sequence, which consists of two 0xFFs, must be written via the DOS interrupt 10H and/or interrupt 21H commands (AH=2 or 9) to the video I/O BIOS routines. After this sequence is detected, the compressed screen file name is expected, followed by a forward slash (/). The control sequence mechanism allows any language to use Saywhat?!. Programmers using C, for example, would use the command **printf** ("\377\377MENU/") to display the screen called MENU. VIDPOP then reads the file from disk, uncompresses and displays the screen, and returns control to the application. The display of the screen is as fast as the Saywhat?! documentation advertises.

Programs that bypass the video I/O BIOS to display text are not able to use the control sequence directly. A separate program called POP.COM corrects this problem. However, it must be run as a batch file, whether through an EXEC call or the equivalent. For example, in Nantucket Inc.'s Clipper or Ashton-Tate's dBASE III, this would look like RUN POP MENU.

Currently the memory-resident VIDPOP program must be installed to display the compressed screens. This is a disadvantage with Saywhat?!. An additional version that is not memory resident should be provided for use in a developer's application. Furthermore, an object file should be provided to display the screens that systems developers can link and/or modify. The compressed images themselves also should be in a form that can be linked and/or compiled. This would allow the developer to deliver only one executable file to an end user, rather than a file for each screen, the memory-resident program, and the developer's application. The earlier versions of the program were not memory resident, and the various programs that were used to load screens in previous versions have been combined in this release.

The handling of pull-down menus is also dealt with by Saywhat?!. Once a text file is displayed, the image can be saved in one of three pages, and a second text file then can be displayed. Restoring the saved image returns the user directly to the original screen. Saywhat?! allows three pages to be saved at once, creating the effect of pull-down menus. These menus also can include data-entry fields; however, the developer must be responsible for coordinating any overlap.

Specifying data-entry fields is provided according to the target-language specifications. Up to 64 data-entry fields may be specified on a screen. By positioning the cursor where the data-entry field should be and entering *G*, the user receives a query to define the field by entering a variable name and optional format specification. A data-entry field can be specified as either input or output but not as both.

Developers can generate source code in one of three languages. Input fields result, for example, in Pascal code using READ with a TYPE declared, dBASE code using GET <var> PICTURE <format>, and BASIC using INPUT. Output fields result in Pascal code using WRITE with a TYPE declared, dBASE using SAY <var> PICTURE <format>, and BASIC using PRINT. The format specification in Pascal is entered in a VAR block as the data type of the variable being read. No syntax checking is done on the data types.

The data-entry source code that is generated is not complete and must be integrated in an application. The generated source code will perform only the operations to display the screen and read the data. Any initialization, which is required in dBASE, must be carried out before the generated code is called. The programmer is responsible for integrating the generated data-entry source code into the application.

When saving the screen and data-entry specifications, MENU for example, several types of files can be generated. MENU.SQZ, the compressed image of the screen, without any data entry information, is always produced. MENU.GET contains the data-entry information if data-entry fields have been specified. This file is not required to display the screen. If dBASE, Pascal, or BASIC output is specified, MENU.RUN is generated with the source code to perform the data entry. MENU.TXT, a normal ASCII representation of the screen without data entry fields, is created when TEXT output is specified.

Saywhat?! can be used for several types of applications. Prototypes, consisting of a series of screens and pull-down menus for demonstrations, can be constructed, without having to write any code. A sample batch file provided with the package can be modified for this use. The code-generation capability is only marginally useful for systems developers, because data initialization and database specification and creation are not provided. Using Saywhat?!, developers can display screens faster and with less clutter in their source code because complicated commands are not required to display attractive screens.

Saywhat?! is easy to learn and easier to use. The documentation is simple to understand and quite adequate in describing the screen editor and the display of screens, although it does not have an index. With this product, screens can be designed and displayed very quickly, saving the applications developer valuable time.

—STEVE JOHNSON

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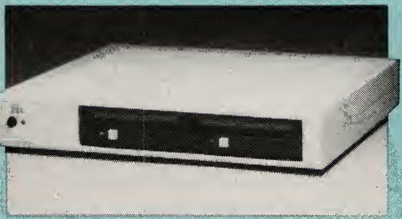

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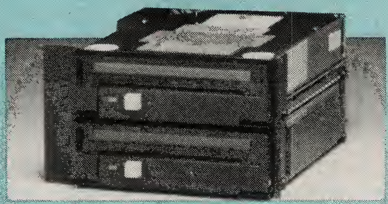

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The storage capacity and speed of hard disks have made them an almost essential part of any microcomputer system that is intended for serious business or technical applications. However, diskettes have their own advantages. They are simple to back up, can be used to transfer data between computers, and can be kept under lock and key to protect valuable or sensitive information. It is possible for users to have the best of both worlds—removable cartridge disks combine the speed and capacity of fixed, hard disks with the convenience of removable media. Two removable cartridge disk systems, the Diskit 2 Plus from IDEAssociates, Inc. and the Durapak from Sysgen, Inc., are reviewed in this article.

The first reliable removable cartridge disk system appeared in 1983 when IOMEGA Corporation introduced the Bernoulli Box. The Bernoulli Box avoided the reliability problems of earlier systems by using a completely different method of maintaining the spacing between the read/write head and the spinning disk. Rather than relying on an inflexible disk and a rigid mechanical structure, the Bernoulli Box uses flexible 8-inch disks and applies a basic principle of physics (Bernoulli's Law) to maintain the spinning disk at the proper distance from the read/write head. (For more information on the Bernoulli Box, see "The Bernoulli Box," Giovanni Perrone, June 1985, p. 145 and "The Bernoulli Box—Update," Product Watch, April 1986, p. 197.)

In contrast to the Bernoulli Box, the IDEAssociates Diskit 2 Plus and the Sysgen Durapak use conventional hard-disk technology. In fact, they use the same drives and cartridges from Syquest Technology. Each cartridge contains a single, two-sided, 3.9-inch diameter hard-disk platter. The half-height drives clamp the disk rigidly in position, rotate it at 3,550 RPM, and position a read/write head over each surface. Once operating, these units function as any nonremovable hard disk, with the head *floating* above the platter on a cushion of air. They can be operated in a horizontal or vertical position.

The nature of removable cartridge disks includes some inherent problems, one of which is cleanliness. The extremely narrow gap between the read/write head and the rapidly spinning disk is smaller than many airborne particles such as dust and cigarette smoke. If a particle gets caught between the head and the disk, problems can result, ranging from minor data loss to a catastrophic head crash. Nonremovable hard disks are manufactured in extremely clean environments and are sealed airtight before leaving the factory. Removable cartridge disks cannot be sealed, however, so the solution is to pass a stream of filtered air through the unit, which prevents unfiltered room air from entering. When the cartridge is out of the drive unit, its internal cleanliness is protected by a spring-loaded door that opens only when the cartridge is inserted in the drive.

Removable cartridge disks are also fragile, although the hard-disk technology used by Syquest is longer lasting than the technology used in the Bernoulli Box, with a media-life expectancy of 11,000 power-on hours. Nonetheless, Syquest warns that a cartridge that has been dropped onto a hard surface from

a height greater than four inches may damage the drive.

A problem can arise if a cartridge is changed while files are open, resulting in data loss. The Durapak and Diskit 2 Plus systems make no provision for this possibility; the user must be responsible for changing the cartridges at appropriate times.

TESTING THE SYSTEMS

The Durapak and the Diskit 2 Plus systems each were installed in an IBM PC with two diskette drives and a 135-watt power supply. For both products, the manufacturer's installation procedure on a PC without a hard disk results in the cartridge drives being designated C: and D:. The system will boot from drive C: if DOS is present on the cartridge. The drives were also installed in a PC-compatible computer (the PC Designs, Inc. FD-1000) that had two diskette drives and a 20MB Seagate hard disk with a Western Digital controller. Both removable cartridge disks again installed smoothly, as drives D: and E:. The only problem was that the Sysgen driver software interfered with reading the battery-operated clock on the FD-1000 motherboard. All of the benchmarks were performed on the IBM PC.

TABLE 1: *Cartridge Disk Specifications*

	IDEASSOCIATES	SYSGEN
PRODUCT	Diskit 2 Plus	Durapak
DISK LOGICAL PARAMETERS		
Surfaces	2	2
Tracks	611	609
Sectors/track	17	25
Bytes/sector	512	512
Sectors/cluster	8	8
Cluster size	4,096	4,096
Total space	10,636,288	15,590,400
DATA ENCODING METHOD	MFM	RLL
WARRANTY	1 year	1 year
MTBF FOR MEDIA (hours)	11,000	11,000

The common Syquest drive and cartridge that these two products share account for the similarity in specifications. The Durapak's RLL encoding, however, provides more capacity on a single cartridge than does the Diskit 2 Plus.

The first step in the test procedure was to determine the removable cartridge disks logical specifications with the program INFO (from the article "Finding Disk Parameters," Glenn F. Roberts, May 1986, p. 112). These data, along with other specifications, are summarized in table 1.

Next, performance was assessed with two hard-disk benchmark programs. The program AUTOTEST (from "Fixed-disk Benchmarks," William J. Hunt, November 1984, p. 64) times sequential and random disk-read operations. Sequential operations, which read data from adjacent disk sectors, are typical of loading large program or data files. Random operations read data from random disk sectors separated by various head-travel distances (expressed as

a percentage of total disk width). They are typical of updating records in a large database, working with files that are fragmented on the disk, and working with a program that requires access to more than one file at once.

The other benchmark program, ATDISK (from "Out from the Shadow of IBM," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 52), uses BIOS calls to determine the low-level hardware operations of track-to-track and average random seek times and effective data transfer rate. ATDISK also uses DOS calls to time normal file operations, by writing, reading, and deleting ten 20KB files. Performance varies with the location of the test files on the disk and the number of I/O buffers. Therefore, this test was done on cartridges that were blank except for the system files and with no FILES= or BUFFERS= statements placed in the CONFIG.SYS file. The results of the benchmarks are given in table 2.

TABLE 2: *Benchmark Results*

	IDEASSOCIATES	SYSGEN
PRODUCT	Diskit 2 Plus[a]	Durapak
ATDISK		
Track-track seek time	67.1	16.9
Average seek time	141.0	86.1
Effective transfer rate (KB/sec)	11.9	5.4
DOS file I/O (sec)	38.2	28.9
AUTOTEST		
Sequential read		
1 sector	66	22
8 sectors	85	49
16 sectors	124	71
24 sectors	148	107
Random 1 sector read		
0.10 width	179	111
0.33 width	206	163
0.50 width	218	188
0.90 width	301	243
Random 8 sector read		
0.10 width	195	121
0.33 width	225	176
0.50 width	266	187
0.90 width	319	250

All times in milliseconds unless otherwise noted
The two drives in each product gave identical or nearly identical benchmark results.
Tests were performed on an IBM PC with two diskette drives and 135-watt power supply.
[a] The Diskit 2 Plus results were taken with the encryption option disabled.

The Durapak's RLL encoding and faster seek times for disk reads provide greater I/O performance with the same drive hardware from Syquest Technology.

IDEAssociates, Inc. The Diskit 2 Plus is a wide, flat unit that can be placed under the monitor. It measures 14½-inches wide, 2½-inches high, and 13½-inches deep. It is joined to the system unit by a 62-pin connector cable 36-inches long. The length of cable is sufficient for placing the Diskit 2 Plus on top of or next to the system unit, but permits few other options. The controller card is a full-length unit that uses modified frequency modulation (MFM) encoding to put 10MB on each cartridge. (See "Mass-storage Mergers," Peter G. Aitken, January 1987, p. 76 for an explanation of the hard-disk encoding methods.)

Each Diskit 2 Plus cartridge is 4⅜-inches square and ⅜-inch thick. A cartridge can be write protected with small plastic tabs that can be snapped into a slot on the cartridge. When a cartridge is not write protected, the tab is loose and can be easily lost.

Each of the Syquest drives used in the Diskit 2 Plus has a cartridge loading door (with a small window that reveals a label placed on the end of the cartridge), an LED indicator, and a release button. When a cartridge is inserted into the drive, it snaps into place; closing the door lowers the cartridge and read/write heads into position and starts the disk spinning. The LED glows red while the cartridge is being brought up to speed and green when it is ready for access; it blinks red during access.

Cartridge removal requires pressing the release button, which causes the disk to stop spinning. During this time, approximately 12 seconds, the LED continues to blink red. Once the disk stops spinning and the indicator light goes out, the release button is pressed again, causing the door to open slightly. Opening the door manually the rest of the way causes the cartridge to pop about halfway out of the drive.

The Diskit 2 Plus comes with an installation program that prepares the boot disk, either creates or modifies AUTOEXEC.BAT and CONFIG.SYS, and performs diagnostics on the hardware elements of the system. Utilities are provided for duplicating cartridges, using Diskit cartridges to back up and restore hard disks, low- and high-level formatting and partitioning of cartridges, and performing diagnostics on cartridges. The interleave value of 1 cannot be changed. The backup program is limited to copying the entire hard disk; selective backup, by date, for example, is not possible.

A unique feature of the Diskit 2 Plus system is its ability to encrypt the data that are recorded on the cartridge disks. Given the portability of the removable cartridges, the possibility exists that a cartridge containing sensitive information could be stolen. If the cartridge is encrypted, it is unreadable by anyone without the password.

During hardware installation, a jumper on the Diskit controller board can be set to allow encryption. If encryption is enabled, the user is asked during each system boot whether both, one, or no cartridges are to be encrypted during this work session. If encryption is selected for one or both disks, the user is then prompted for a key word (up to eight characters) for each encrypted drive. Encryption, along with a given key word, applies to an entire cartridge; it is not an option to encrypt only some of the files and not to encrypt any others.

The encryption scheme used by the Diskit 2 Plus is contained in the controller-board ROM. It is based on the Data Encryption Standard issued by the National Bureau of Standards and is claimed to be next to impossible to break. The instruction manual warns that if a user forgets the key word, data cannot be recovered (although the cartridge disk can be reformatted and used again). Encryption adds 10-15 percent to the time needed to write files, but does not appear to increase read times.

The Diskit 2 Plus instruction manual is printed on 5½-by-8½-inch pages that are hole-punched for insertion in a binder (not supplied). The printing quality of the manual is mediocre, but the quality of the contents is excellent.

A disk-maintenance kit is included with the Diskit 2 Plus package. This is not a head cleaner, but rather cleans the disk spindle inside the drive units. Each Syquest drive has a flat metal spindle attached to the shaft of the drive motor. This spindle, which is magnetized, mates to a flat metal hub on the cartridge disk. A close alignment between these two plates is necessary for the unit to function properly. If the spindle attracts dust or, because of its magnetism, metallic particles, this alignment can be disrupted. The cleaning kit is a plastic cartridge shell with foam inserts. When it is inserted into the drive and the door is closed, the spindle rotates against the foam insert. The cleaning fluid is not supplied; isopropyl alcohol or Freon should be used.

Sysgen, Inc. The Durapak system consists of drives and disk cartridges that are mechanically identical to those used in the Diskit. Three configurations are available: single internal drive, dual internal drives, and dual external drives. The dual external unit is similar in shape and size to the Diskit 2 Plus system; the dual internal drive, which requires a 135-watt or larger power supply, was used for this review.

The two half-height drives are mounted together on a bracket with a small cooling fan located at the rear. The package fits in either full-height diskette-drive bay on a PC/XT. It connects to the controller card (a full-length unit made by Adaptec) via one 34-wire and two 20-wire ribbon cables. These cables are more than 3-feet long, which is considerably longer than the maximum that would be needed to connect drives in the right diskette bay to a controller card in the left-most expansion slot. This extra length makes it difficult to route the cables within the computer. Care must be taken to avoid interfering with the flow of cooling air.

The Sysgen controller uses run length limited (RLL 2,7) encoding, which enables 15MB to be stored on each cartridge. This encoding method also permits faster data-transfer rates than does MFM (7.5 versus 5 MHz), which partly accounts for the Durapak's speed advantage over the Diskit 2 Plus. The rest of the Durapak's speed advantage results from a modification in the way the Syquest drive positions the

read/write heads. Usually, three rotations of the disk are required to locate a particular track. This degree of accuracy in head positioning is necessary during write operations, but optional when reading from the disk. The Sysgen unit dispenses with the two unnecessary disk rotations during read operations, resulting in faster performance.

The Durapak manual consists of 8½-by-11-inch pages in a spiral binding. Instructions for physically installing the hardware are very clear and complete. An automated installation program is not included, but the instructions for copying the device driver program and modifying CONFIG.SYS are clear enough that even a computer novice can follow them with little trouble. Utilities are provided for high-level formatting of cartridge disks, making image copies between hard disks, repartitioning cartridge disks, and performing diagnostics on the drives and disks. A low-level format program is not provided; the cartridges are supplied with the hard format already done (the same is true of the Diskit 2 Plus cartridges).

Sysgen does not supply a drive-cleaning kit with the Durapak. Given the sensitivity of these units to contamination, the user should consider purchasing the kit sold by IDEAssociates for the Diskit system.

The advantages of removable cartridge disks come at a price. Both systems are much more expensive than a system consisting of an equal capacity hard disk with tape backup. The problems of cartridge reliability and fragility also must be considered. For many people, the advantage of virtually unlimited storage in 10MB or 15MB increments outweighs the disadvantages.

The IDEAssociates Diskit 2 Plus offers a secure data encryption option that may be of interest to some. Note, however, that equally secure, though less convenient, data encryption is available through add-ons such as Borland's SuperKey program. The Diskit 2 Plus offers less storage, is significantly slower than the Durapak, and is more expensive. This unit, as presently priced and configured, does not seem a good choice unless its effortless encryption capability is necessary.

While it is not remarkably fast, the Sysgen Durapak turns in a respectable performance roughly equivalent to that of the standard XT hard disk. If 15MB per cartridge is sufficient for the user's needs, the Sysgen system delivers the best price/performance ratio.

—PETER G. AITKEN

The Plot Thickens

The guidelines for incorporating good human factors into software require intensive, ongoing analysis of an application environment.

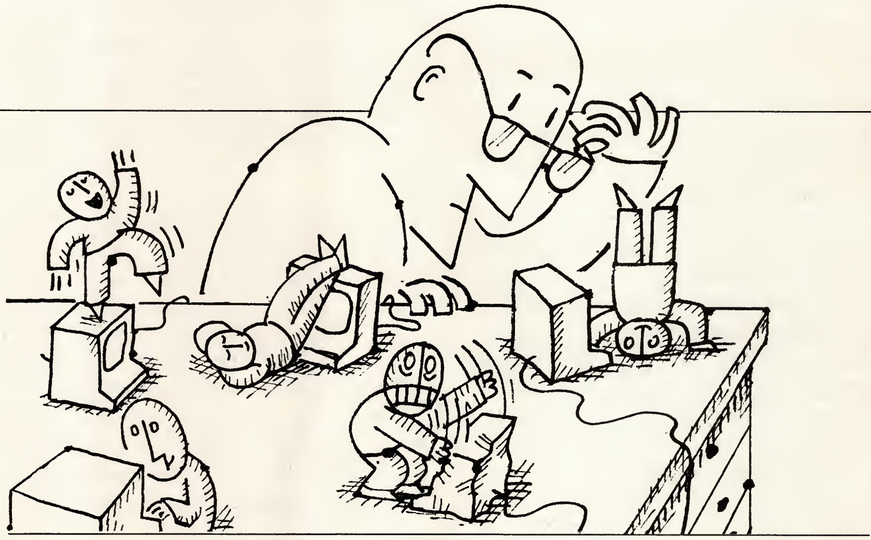

ILLUSTRATION • MACIEK ALBRECHT

In my last article in this column (see "Three Misconceptions," February 1987, p. 187), I drew attention to an issue that I consider fundamental to the promotion of good human factors in computer software. This is the identification of subtle misconceptions about the field. The three misconceptions I addressed at that time were:
- The primary goal is to help novices.
- Users are comfortable with subsets.
- Human engineering is not particularly a technical matter.

The article was presented out of the need to rectify such misconceptions, lest we become a few nice guys promoting (simplistic) virtue.

I now would like to give my second list of misconceptions, this set consisting of four ideas. They are:
- Users should help design systems.
- Menu systems are easier to use than commands.
- Human engineering centers on a few key design issues.
- Human factors are chiefly a matter of personal taste.

I will address this second set as I have the first, pointing out some of the pitfalls and other obvious flaws in making such assumptions.

Users should help design systems. The goal of human engineering is to support the user. But the problem is how to do it. We certainly want to observe how users make use of the system—we want to notice their errors, observe their behavior patterns, and help them perform their tasks. Users, however, often do not have a clear idea of what techniques, what features, and, more importantly, what larger designs work in practice. Because of a lack of experience, users can be their own worst enemies. They often call for more and more features to accommodate the application. Yet the best solution may be to outthink the problem, outthink the application, and provide a simple set of features that integrate into a simple whole.

Designing a system that meets user needs is a sophisticated and difficult task, one that requires a complete and specialized set of skills. It can be accomplished only by experts with creative ideas who have spent years observing users and who understand the deeper issues in human engineering. The skills for producing effective software are not developed overnight. In short, the user should be the center of design, but the design should come from experienced systems designers.

Menu systems are easier to use than commands. It is certainly true that menus enhance recall. I would rather glance at 300 menu entries (that are suitably structured, of course) than try to recall 300 commands. However, recall is not the issue I want to address; it is, instead, the ease of day-to-day usage, assuming that recall is not an obstacle.

A perception persists that menus are easier to use than typed commands (some issues concerning the use of menus are listed in the accompanying table). A similar perception says that icons (that is, visual images on the screen) and special-purpose keys are also easier to learn and use. In short, command languages seem to fall in last place from an ease-of-use standpoint.

When talking about command languages, each of us has some idea of what a *command* looks like. To some, commands may suggest forms such as

SAVE datafile := newdata	(saving a file)
REPLACE /xxx/yyy/;G	(global replace of xxx)

These commands have a notational style of syntax. Commands such as

SAVE datafile AS newdata
CHANGE ALL "xxx" TO "yyy"

have a more prose-like syntax. Thus, in comparing various styles, different ways of embodying a given style must be considered: a good menu system is superior to a poor command language; a set of well-orchestrated, special-purpose keys is superior to a poorly designed menu strategy. But let us assume the same level of excellence, obscurity, or kind of thinking in comparing a menu strategy to a command strategy.

Consider the following menu:

USE DIRECTORY
FILING FUNCTIONS
PAGE CONTROL
CALCULATION
EDITING FUNCTIONS
DATA PROCESSING
MAIL
MANUAL

Such a menu might appear at the top level of an office automation system. Its

intent is to steer the user into one of the major subsystems for further action.

Some difficult issues are apparent here. First of all, does the above list of eight menu choices cover the system? That is, are other applications or subsystems available to the user? The menu implies that no other choices exist, but the truth may be otherwise.

Looking more closely at the menu, we also see an inconsistency with the language that must be resolved. The first entry is a verb phrase, while the second entry is a noun phrase, and the fourth is a simple noun. The last entry is ambiguous. Most menu systems have these kinds of problems; designing a consistent, clear syntax is difficult.

The wording itself is also a difficult issue. Consider, for example, the phrase EDITING FUNCTIONS. To most users, the word FUNCTIONS implies a library of routines. What is probably meant here instead is a generalized text editor, not a set of predefined mathematical functions. The editor probably uses special-purpose keys (not function calls) to enter and correct text.

The meaning of the phrases FILING FUNCTIONS and USE DIRECTORY is likewise unclear. Files might be stored in a directory. Does the directory include file names? Do the filing functions allow someone to look at the directory? And if someone is editing a file, which selection is used, FILING FUNCTIONS or EDITING FUNCTIONS?

Notice the order of the items. The directory, filing, and editing choices seem to go together, but they are not listed together. The calculator, an odd item on the list, is stuck in the middle. The most frequently used function on this menu may be the mail option, which is in seventh place; moreover, those who are mail users only can (subconsciously) become intimidated by the constant reminder of features they do not understand or need.

TABLE: *Menu Considerations*

Covering all possibilities
Consistent phrasing
Choosing the right words
Appropriate grouping
Choosing what to include
Going from one menu to another
Showing how menus relate
Providing needed data

Menus are not as easily implemented as it may seem, and although some applications are suited to a menu structure, others will work better if the user can learn a set of commands.

Menus are a valid design choice. They are attractive in many settings. However, they create their own problems. For a system with only 10 or 20 possible choices in all, the menu structure is easily handled. But for more complex systems, menus are not a blank check for achieving the best user interface. Their merits should be weighed against command languages and any other general design strategies.

Human engineering centers on a few key design issues. The choice of a menu or command strategy is a major design decision in a system. Other major choices are the size of the screen, the method of cursor movement, whether to have on-line help, how to deal with multiple windows on a screen, and so on. These decisions are important because they are fully visible to the user who encounters the system.

The misconception here is the belief that once these decisions are made, the major requirements of human engineering have been met. On the contrary, the myriad of follow-up details can so overwhelm any broad design strategy that the human factors can become lost in the process.

Consider the simple use of the Enter key. This key is normally used to terminate a line of input text. It is also used as a kind of "do it" key to initiate actions. It can be used for:

- indicating acknowledgments
- terminating data entry to an application program
- moving the cursor down the screen to a new line
- supplying a default response, such as yes for a yes/no question.

Such overloading of the Enter key can confuse users. (Do I hit the Enter key or not?) This issue is important because the Enter key is featured in every interaction with every user at every session at the keyboard. It is one of the most pervasive elements in design.

Another detail is the abbreviation rule used to enter command words. One common abbreviation rule states that any key word can be abbreviated by one or more initial letters as long as the initial letter sequence distinguishes it from all other key words. For example, if we only have the key words REFORMAT, READ, SEND, PRINT, and RUNOFF, then we can use the abbreviations REF, REA, S, P, and RU.

This rule requires a user to know all key words in the system in order to

remember the shortest abbreviation. In practice, the user generally does not know all of the key words, but will eventually abstract some informal rules that tend to the job. In the case above, the user might conclude that typing three letters for any word beginning with *R* is sufficient to do the job and go ahead with three letters, even for the key word RUN. This is a situation that produces uncertainty and intimidation in the mind of the user.

Many other such details of design require consideration—the prompting symbol or prompting message for user input, the method for selecting menu items (which can be, for example, by number, by letter, or by cursor movement), the keys for correcting small typing errors, the initial user dialogue, or the conventions for printing a file. These so-called details can have great impact on the user because their frequency of use is so high—all users face them all the time.

Human factors are chiefly a matter of personal taste. I have heard this argument offered in different contexts. The gist of it is that what is fine for one user may not be fine for another—that human-factor considerations all boil down to a matter of personal preference.

Example: consistent behavior. On some systems, cursor movement is highly irregular—that is, bursts of speed are followed by delays and sometimes a creeping movement. Some users may be bothered by this irregularity, and trying to move the cursor to a given position can be difficult. Indeed, it is easy to overshoot when the cursor is delayed, or fall short when the cursor is temporarily moving fast and the button is prematurely released. The programmer would need to do some work to find an appropriate speed for the cursor and thus reach a happy medium. But it seems that some reasonable and consistent speed can be found that satisfies almost all users.

Example: politeness. Imagine for a moment that the user wants to clean the files in a directory to release some storage space. Because he is uncertain which files are still about, a call is made for a listing of all the files in the directory. The directory shows 20, and the list fits comfortably on the screen. The user notices two or three files to delete. Because a menu system is in use, a return must be made to the menu for file deletion. When this action is made, the list of files previously on the screen disappears. The menu has replaced the file list. What happens if the user cannot remember what the file names were or exactly how they were spelled?

Example: muscle stress. Suppose the user is working on a system in which cursor movement and item selection are done with a mouse. For some operations, the mouse button may need to be held down for a period of time. This can occur when a section of text is highlighted or when windows are moved on the screen. The mouse button must be held down until the operation is completed. An operation of this kind can be frequent if not continuous. Because it is easy to release the button prematurely and lose the entire operation, most users will put more pressure on the button than is otherwise needed; this is a normal human reaction. But what is the result? Over prolonged periods of use, a user's arm and neck will be subject to undue muscle stress. This is not a taste issue.

Example: screen layout. Suppose the programmer has some latitude about where to put a particular collection of information on the screen. In a game-playing program, for example, the playing board can be displayed in the upper-left-hand corner of the screen, the center, or the bottom. Similarly, the programmer can designate an area of the screen in which to report ongoing results of the game or error messages. This can be across the top of the screen, in the upper-right-hand corner, or down at the bottom. Are these decisions a matter of taste?

I think not, but the answer is not simple. It depends upon other matters in system design. Some elements of taste will come into play, but much more depends on logic. Most systems require a host of features that must somehow harmonize if the program is to be considered a success. Whether or not the board is put in the upper-left-hand corner of the screen may depend quite markedly on other factors—for example, whether the screen has room for a game history. Collectively, these decisions may interact in subtle ways. One reasonable way to determine a good positioning strategy is to test the matter with potential users. There, in the context of related decisions, it is more natural to observe which scenario seems to work best. My guess is that more often than not, one or more choices will emerge as superior.

Henry F. Ledgard, Ph.D., is a consultant, specializing in software engineering audits, education, and human factors. He has written several books on programming style.

Updated Algorithms

A student of Knuth updates and supplements his teacher's standard textbook on algorithms.

Algorithms
Robert Sedgewick (Reading, MA: Addison-Wesley Publishing Company, Inc., 1983) 552 pages; hardcover, $34.95

The standard handbook on algorithms has long been Donald E. Knuth's *The Art of Computer Programming* (Addison-Wesley, 1973-1981). But Knuth's multivolume set has its limitations: only three of the volumes have appeared so far, they omit some recent developments, and the algorithms are not expressed in a standard programming language. *Algorithms*, written by Robert Sedgewick, one of Knuth's students, fills the gap nicely. This collection of classic algorithms is filled with examples in Pascal that are designed for easy translation into other languages. It can be used either as a textbook (with exercises at the ends of the chapters) or as a reference book.

The first chapter presents the mathematical analysis of algorithms. The running time of any algorithm is proportional to some function of the number N of input data items—perhaps N^2, N^3, or $N \log N$. Sedgewick translates these functions into intuitive rules of thumb, such as, an N^2 algorithm typically has two innermost loops, one inside the other, each iterated N times. An N^3 algorithm has three such loops.

The remaining 39 chapters are grouped into seven sections. The first covers mathematics—not necessarily in the arithmetic sense. For example, Sedgewick's explanation of the addition of polynomials turns out to be a data-structuring problem elegantly solved with linked lists. Other chapters in this section deal with random number generation, curve fitting, simultaneous equations, and numerical integration.

The next topic is sorting. Sedgewick's advice is to abandon the bubble sort traditionally taught in programming courses in favor of the selection sort, which is both faster and easier to remember. He covers all of the basic algorithms, including Shellsort, Quicksort (with and without recursion), Heapsort, radix sorting, and merging. After sorting comes, of course, searching, including the use of balanced trees, B-trees, other kinds of search trees, hashing, and indexed sequential files.

The chapter on string processing is one of the most enlightening of the book. Suppose a user wants to know whether the string CAD occurs as part of another string ABRACADABRA. The obvious, or as Sedgewick calls it, the "brute-force" way to find out is to try matching CAD with every sequence of three letters contained in ABRACADABRA. In this example, CAD does not match the first three letters attempted, ABR. Clearly, it will not match if shifted one space, or even two spaces, because R is not found anywhere in CAD. At this rate, a match would not be made until the fifth try. Sedgewick suggests a more efficient alternative, the Boyer/Moore right-to-left, pattern-scanning, search algorithm. By moving completely past the R in ABR before trying again, two steps can be eliminated.

Sedgewick presents this algorithm in ready-to-run form. He also mentions the Knuth/Morris/Pratt algorithm, which achieves a comparable gain in efficiency by "learning from" partial matches that are found already. These algorithms are recent discoveries (1977) and many reference books do not mention them.

The author then moves on to the topics of pattern matching and parsing. A parser is a program that recognizes the syntactic structure of its input, which may be in a programming language, a human language, or a mathematical notation. After illustrating top-down and bottom-up parsing methods, Sedgewick gives an example of a compiler and covers programs that generate compilers automatically.

Data compression and cryptography are covered next. Sedgewick describes public-key encryption briefly (a full discussion would fill a book). He points out that the most secure encryption system is not the new public-key system, but the time-honored Vernam cipher, which is impossible to crack if the key is as long as the message.

Two units deal with sets of points and connections between them. Some of the algorithms presented in these sections have obvious uses in computer graphics, such as how to draw a polygon around an arbitrary set of points. Other geometric algorithms are useful with data that can be represented in a diagram. Examples include designing printed circuit boards, planning travel routes, and analyzing flowcharts.

Many of the applications included in the book involve the use of *directed graphs*, which are, roughly, sets of nodes connected by one-directional arrows. Directed graphs can represent dependencies between items. For example, the nodes might represent parts of a project, while the arrows indicate which parts must be completed before other parts are begun. The nodes might also represent routines in a large program, with the arrows indicating which routines call other routines.

Although this book can be used purely for reference, readers will miss a great deal if they do not work through it from beginning to end. Fundamental discussion of recursion, for example, appears in several places, most noticeably under Quicksort. The book includes plenty of references to related literature for readers who want to pursue topics that are mentioned briefly.

Robert Sedgewick's *Algorithms* gets excellent marks. It will be a basic reference work for many years.

—MICHAEL A. COVINGTON

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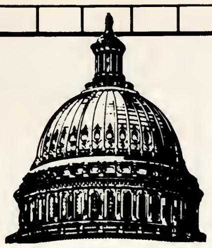

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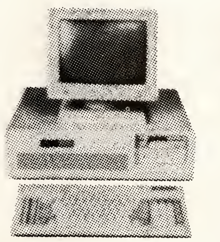

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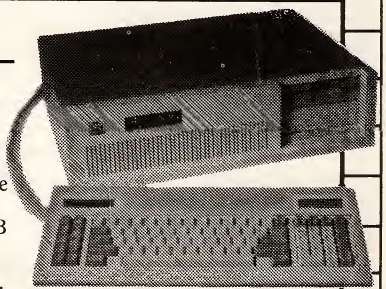

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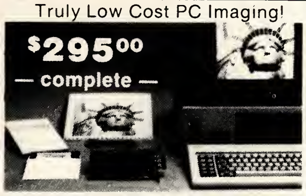

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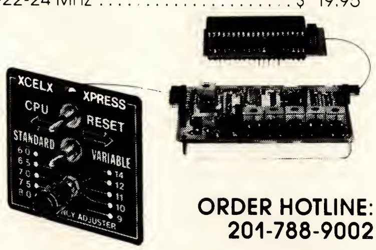

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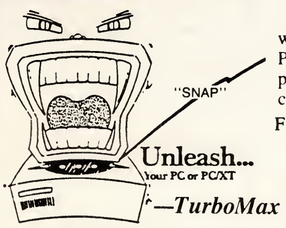

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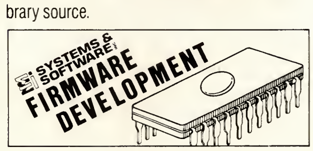

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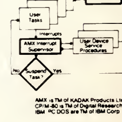

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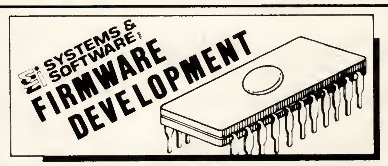

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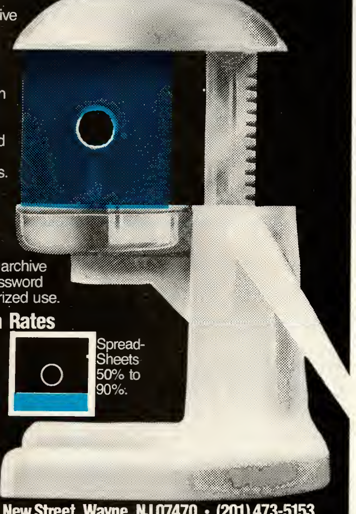

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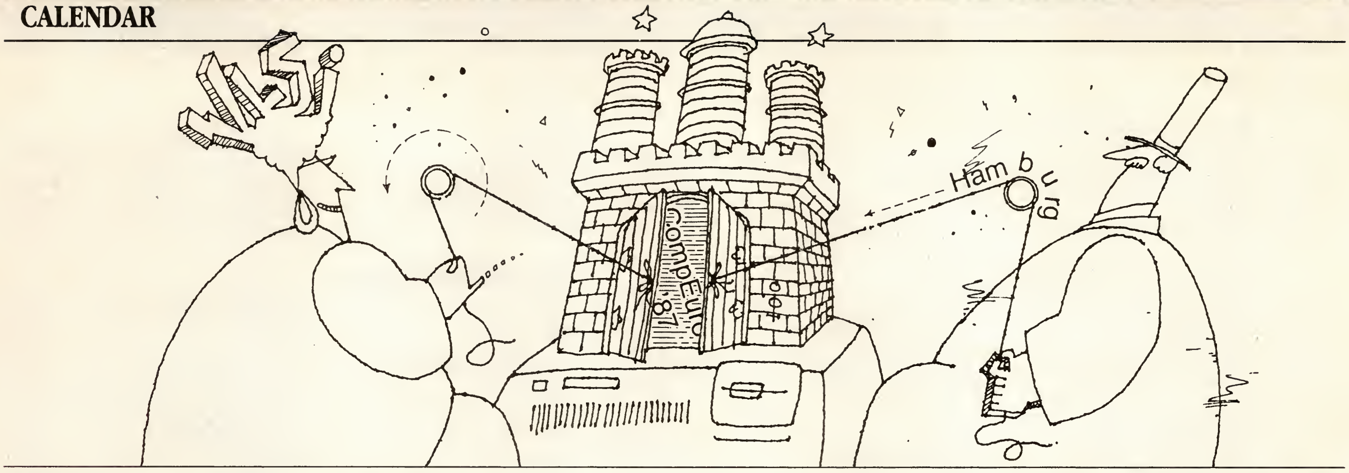

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Symposium on LANs and Micro/Mainframe Links
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May 7–9
Desktop Productivity
New York, NY (FORTUNE and Seybold) *Contact:* The Seybold Group, 100 Homeland Court, San Jose, CA 95112; 408/297-0888

May 11–13
Design and Test of Application-Specific Integrated Circuits
Cherry Hill, NJ (IEEE) *Contact:* Workstation Technology and Systems Workshop, Ralph J. Preiss, 12 Colburn Dr., Poughkeepsie, NY 12603; 914/435-8185

May 11–13
Desktop Publishing '87
San Francisco, CA (Online International) *Contact:* Carol Peters, Online International, 989 Avenue of the Americas, New York, NY 10018; 212/279-8890

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CD-I/The Future
San Francisco, CA (Online International) *Contact:* Carol Peters, Online International, 989 Avenue of the Americas, New York, NY 10018; 212/279-8890

May 11–15
CompEuro '87: VLSI and Computers
Hamburg, W. Germany (IEEE-CS and Gesellschaft für Informatik) *Contact:* Dr. W. E. Proebster, IBM P.B. 80 08 80, D-7000 Stuttgart 80, W. Germany

May 13–15
History of Scientific and Numeric Computation
Princeton, NJ (ACM) *Contact:* Hank Friedman, CIS Dept., Room 303, Computer Center Building, Temple University, Philadelphia, PA 19122; 215/787-8450

May 13–16
Computer Applications in Medicine and Health Care
San Francisco, CA (AAMSI) *Contact:* American Association for Medical Systems and Informatics, Suite 700, 1101 Connecticut Ave. NW, Washington, DC 20036; 202/857-1189

May 18–19
AI and Expert Systems
Cincinnati, OH (ASM) *Contact:* Association for Systems Management, 24587 Bagley Rd., Cleveland, OH 44138; 216/243-6900

May 26–28
Multiple-Valued Logic
Boston, MA (IEEE-CS) *Contact:* Dan Simovici, Math/CS Dept., University of Mass., Boston, MA 02125; 617/929-7966

May 27–29
Data Communications
New York, NY (AMA) *Contact:* American Management Association, P.O. Box 319, Saranac Lake, NY 12983; 518/891-0065

JUNE

June 1–4
COMDEX/Spring
Atlanta, GA (Interface Group) *Contact:* The Interface Group, 300 First Ave., Needham, MA 02194; 617/449-6600

June 3–5
AI/Europa '87
Frankfurt, W. Germany (TCM) *Contact:* Tower Conference Management, 331 W. Wesley St., Wheaton, IL 60187; 312/668-8100

June 3–5
Internetworking and Protocols
Newport Beach, CA (CAPE) *Contact:* Center for Advanced Professional Ed., 1820 E. Garry St., Suite 110, Santa Ana, CA 92705; 714/261-0240

June 3–5
Research and Development on Information Retrieval
New Orleans, LA (ACM SIGIR and ACM SIGART) *Contact:* Donald H. Kraft, CS Dept., Louisiana State University, Baton Rouge, LA 70803; 504/388-1495

June 8–12
USENIX Technical Conference
Phoenix, AZ (USENIX) *Contact:* USENIX, P.O. Box 385, Sunset Beach, CA 90742; 213/592-1381

June 11
Next Generation Information Systems
Gaithersburg, MD (ACM and U.S. Dept. of Commerce) *Contact:* U.S. Dept. of Commerce, National Bureau of Standards, Gaithersburg, MD 20899; 301/290-6208

June 11–12
Manager's Guide to End User Computing
Atlanta, GA (GIT) *Contact:* Deidre Mercer, Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385; 404/894-2547

June 15–17
Localnet East
New York, NY (Online International) *Contact:* Carol Peters, Online International, 989 Avenue of the Americas, New York, NY 10018; 212/279-8890

June 15–18
1987 National Computer Conference
Chicago, IL (AFIPS and ACM) *Contact:* NCC 87, AFIPS, 1899 Preston White Dr., Reston, VA 22091; 800/622-1987; in Virginia, 703/620-8955

June 16–18
COMDEX International '87
Nice, France (Interface Group) *Contact:* The Interface Group,, 300 First Ave., Needham, MA 02194; 617/449-6600

June 24–26
Interpreters and Interpretive Techniques
St. Paul, MN (ACM SIGPLAN and IEEE-CS) *Contact:* Mark S. Johnson, HP Labs, 1501 Page Mill Rd. 3u24, Palo Alto, CA 94304-1181; 415/857-8719

JULY

July 6–16
Summer Institute on Educational Computing
New Rochelle, NY (Iona College) *Contact:* Brian Monahan, CIS Dept., Iona College, New Rochelle, NY 10801; 914/633-2578

July 21–23
Optical Memory Technology
San Francisco, CA (Rothchild Consultants) *Contact:* Rothchild Consultants, 256 Laguna Honda Blvd., San Francisco, CA 94116-1496; 415/681-3700

July 27–31
SIGGRAPH '87
Anaheim, CA (ACM SIGGRAPH) *Contact:* SIGGRAPH '87, Smith, Bucklin, and Associates, 111 E. Wacker Dr., Suite 600, Chicago, IL 60601; 312/644-6610

AUGUST

August 17–20
Engineering and Manufacturing
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August 19–21
COMDEX/Australia
Syndney, Australia (The Interface Group) *Contact:* The Interface Group, Inc. 300 First Ave., Needham, MA 02194; 617/449-6600

August 22–28
IJCAI '87
Milan, Italy (International Joint Conferences on Artificial Intelligence) *Contact:* John McDermott, CS Dept., Carnegie-Mellon University, Pittsburgh, PA 15213; 412/268-2599

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Seattle, WA (American Association for Artificial Intelligence) *Contact:* Lorraine Cooper, AAAI, 445 Burgess, Menlo Park, CA 94025; 415/328-3123

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102	117	132	147	162	177	192	207	222	237	252	267	282	297	312	327	342	357	372	387
103	118	133	148	163	178	193	208	223	238	253	268	283	298	313	328	343	358	373	388
104	119	134	149	164	179	194	209	224	239	254	269	284	299	314	329	344	359	374	389
105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	360	375	390
106	121	136	151	166	181	196	211	226	241	256	271	286	301	316	331	346	361	376	391
107	122	137	152	167	182	197	212	227	242	257	272	287	302	317	332	347	362	377	392
108	123	138	153	168	183	198	213	228	243	258	273	288	303	318	333	348	363	378	393
109	124	139	154	169	184	199	214	229	244	259	274	289	304	319	334	349	364	379	394
110	125	140	155	170	185	200	215	230	245	260	275	290	305	320	335	350	365	380	395
111	126	141	156	171	186	201	216	231	246	261	276	291	306	321	336	351	366	381	396
112	127	142	157	172	187	202	217	232	247	262	277	292	307	322	337	352	367	382	397
113	128	143	158	173	188	203	218	233	248	263	278	293	308	323	338	353	368	383	398
114	129	144	159	174	189	204	219	234	249	264	279	294	309	324	339	354	369	384	399
115	130	145	160	175	190	205	220	235	250	265	280	295	310	325	340	355	370	385	400

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106	121	136	151	166	181	196	211	226	241	256	271	286	301	316	331	346	361	376	391
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110	125	140	155	170	185	200	215	230	245	260	275	290	305	320	335	350	365	380	395
111	126	141	156	171	186	201	216	231	246	261	276	291	306	321	336	351	366	381	396
112	127	142	157	172	187	202	217	232	247	262	277	292	307	322	337	352	367	382	397
113	128	143	158	173	188	203	218	233	248	263	278	293	308	323	338	353	368	383	398
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